Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

HOW TO SELECT A STAINLESS STEEL

MANUAL NO. 155

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JANUARY, 1959

ALSO: MOLYBDENUM COATINGS WHERE TO USE URETHANE FOAMS COMPLETE CONTENTS—PAGE 1

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Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

JANUARY 1959
VOL. 49, NO. 1

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Easy Maintenance of Nuclear Power Plants ..... *W. Fleischmann, S. Williams* **73**
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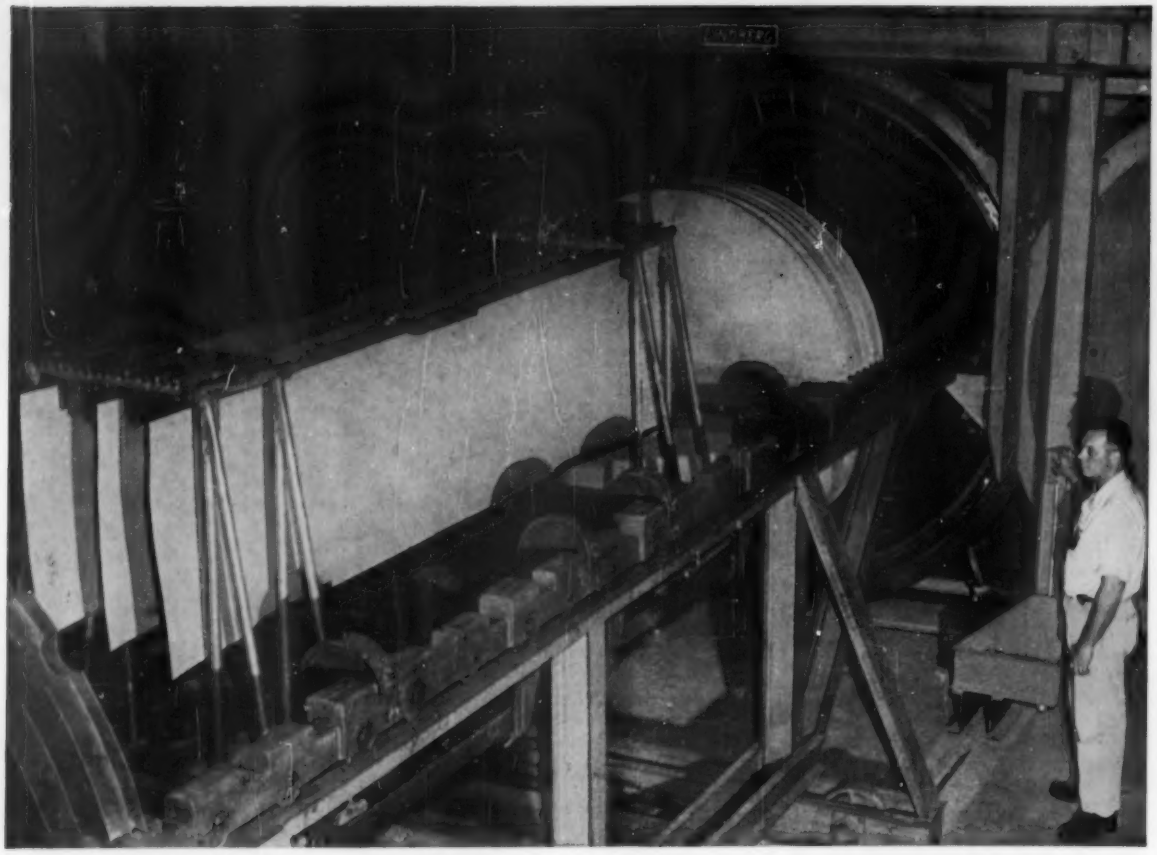
COVER BY HARRY & MARION ZELENKO



TAKES BIG ONES. This is the world's largest vacuum heat-treating furnace. Built by Lindberg Engineering Company, it degasses and anneals full-sized titanium alloy sheets in the flat, is also used for large forgings and extrusions. Work chamber of Inconel alloy is 14 feet long, 6 feet in diameter.

Getting space-bound metals ready to go

Metals like titanium and zirconium used in guided missiles are tricky to heat treat.

It's not so hard to imagine what usually happens as temperatures soar in the heat-treating furnace . . . these metals tend to "pick up" hydrogen, oxygen and nitrogen.

They become brittle. They crack under stress.

To put a damper on that, a degassing furnace like the one shown here is used. It runs so hot — at so high a vacuum — there's practically no gas left to worry about!

Under those conditions, you might wonder if its users wouldn't be worrying about how the furnace itself would react. No problem on that score, either. The huge retort — big enough to take full-size sheets in the flat — is made entirely of Inconel* nickel-chromium alloy. *Half-inch plate.*

With this protection, metals can be heated as high as 2100°F in a vacuum of 0.3 microns without danger of collapsing the retort. Inconel alloy has all the strength, all the resistance to oxidation, that's required for such gruelling service.

Then, too, Inconel alloy gives long-term insurance against damage by thermal shock. And another big consideration: it is easy to fabricate in the large and heavy sections that are needed.

Do you have a metal problem in which high (or low) temperatures are a major headache? Or corrosion? Stress? Fatigue? Some other troublemaker? There is a good chance Inconel or some other Inco Nickel Alloy will provide the combination of properties you need. To find out more about these versatile alloys, write for Inco's 'round-up' booklet, "Standard Alloys for Special Problems."

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What's new IN MATERIALS

...AT A GLANCE

Ductile vanadium now joins the group of metals available as foil, drawn wire, extruded tube, plate, sheet and rod. Pure vanadium is soft and ductile, has a relatively low neutron cross section (5.1 barns), and has excellent corrosion resistance. Titanium appears to be the most promising alloying element for improving the strength of vanadium-base alloys at both room and high temperatures. (More details in a forthcoming issue.)

Source: Vanadium Corp. of America, 420 Lexington Ave., New York 17.

New plastics materials highlighting the 8th National Plastics Exposition held recently in Chicago include: 1) *four modified alkyds* that retain extremely high insulation resistance after moisture exposure; 2) *phenolic-melamine copolymer* combining colorability with low cost; 3) *nylon (type 6) sheet and film* in widths up to 60 in.; and 4) *plastics foams in film form* (polyethylene and polystyrene). (Watch for more details next month.)

Longer die life in the production of steel parts can be obtained by using molybdenum disulfide, recent field tests indicate. Tests show the life of a die used to turn out steel caster parts was extended four times its normal life when lubricated with molybdenum disulfide. Previously, the die had to be removed after 20,000 pieces were produced; now it can be used for a production run of 100,000 pieces.

Source: Climax Molybdenum Co., Div. of American Metal Climax, Inc., 500 5th Ave., New York 36.

Flameless sealing of glass to glass is an inexpensive method for packing transistors and rectifiers. The developer of this method says, "Where previous electronic components were encapsulatd at a 15¢ unit cost, the same components can now be hermetically sealed with the flameless method for as little as 3¢ each." In the process, a metal ring is inserted in powdered glass and heated by an induction coil; heat causes the glass to flow, creating an airtight seal.

Source: Trans-Sil Corp., 55 Honeck St., Englewood, N. J.

A high strength shear bolt is said to be 71% stronger than currently used aircraft bolts. Made of 5% chromium hot work die steel, the bolt has a minimum shear strength of 156,000 psi; shear strength of currently used aircraft bolts is 70,000 psi.

Source: Standard Pressed Steel Co., Box 888, Jenkintown, Pa.

A clear anodic coating for magnesium has been developed that can be applied in less than 1 min. Used under lacquer or varnish, the anodic coating is said to afford maximum corrosion protection to magnesium parts. In 20% salt spray tests, coated magnesium plus lacquer or varnish has passed 500 hr with virtually no change in appearance. (More details next month.)

Source: Dow Chemical Co., Midland, Mich.

Larger and lower cost investment castings may result from the development of several new ceramic shell molding techniques, according to a recent industry report. Although ceramic mold casting is not new, there has been a continuing effort to

develop a thin-walled ceramic shell that would give 1) reduced time for melt-out and firing schedules, and 2) faster cooling of cast metal. One such mold has turned out steel castings with good surface characteristics and good dimensional stability. (More details in a forthcoming issue.)
Source: Investment Casting Institute, 27 E. Monroe St. Chicago 3.

An exceptionally clear transparent plastic, a copolymer of styrene and methyl methacrylate, has good weathering characteristics and is easy to process. The thermoplastic has a tensile strength of 9000 psi, an elongation of 5%, a Rockwell hardness of M78, and an impact strength of 0.4 ft-lb per in.; it costs about 49¢ per lb. Potential uses include light fixtures, outdoor signs, boat windshields, dials, automobile horn buttons, medallions, knobs, decorative items and escutcheons for major appliances. (More details next month.)
Source: Dow Chemical Co., Midland, Mich.

Longer wearing, more moisture resistant leather can be obtained by impregnating leather throughout its thickness with butyl rubber or polybutene, recent research indicates. Tests show moisture resistance of ordinary leather is increased 35% and wear life 50% by impregnation.
Source: Rpt. No. 2270, U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

A better understanding of the structure of matter has been realized with a new technique that vibrates atoms back and forth up to 20 million times a second. Vibration upsets the atoms' magnetic balance, and the unbalance is detected by electrical signals. The technique has been used successfully in studying the structure of semiconductors.
Source: Westinghouse Electric Corp., Box 2278, Pittsburgh.

Relatively inexpensive aluminum magnet wire in AWG sizes 12 through 24 is now on the market. The wire will be manufactured chiefly with three types of insulation: Formvar, Nyform and Isonel. The wire has potential use in coils, motors, generators and solenoids.
Source: Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19.

A moisture resistant glass capacitor, currently in pilot production, is guaranteed to show no significant change in capacitance or increase in dielectric loss after more than 1000 hr in high humidity atmospheres. Moisture resistance is made possible by: 1) a new sealing technique that provides a strong, airtight, glass-to-metal seal, and 2) a fusion seal around the perimeter of the part.
Source: Corning Glass Works, Corning, N. Y.

More heat and corrosion resistant nuclear equipment may result from the development of a new group of composite materials called Sinterwrought. The materials, made of metal powders uniformly dispersed with carbides, borides, oxides and intermetallic compounds, are formed into various shapes by extruding and rolling. Typical materials: stainless steel-samarium oxide foil, aluminum-dysprosium oxide strip, and stainless steel-zirconium boride rod. (More details in a forthcoming issue.)
Source: Sintercast Corp. of America, 184 Woodworth Ave., Yonkers 2, N. Y.

Turn to page 115 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*

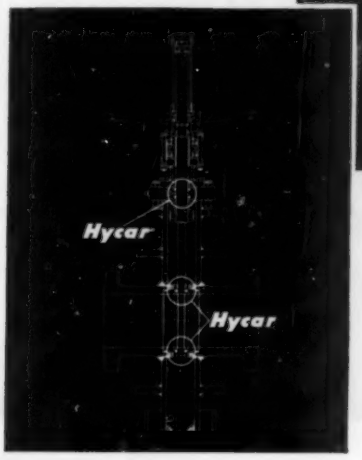
Lubrication-free gate valves use "O" ring seals of *Hycar*

These fabricated steel gate valves prove the extra abrasion resistance and resilience you get from Hycar nitrile rubber in tough oil field operations. Their parallel-sided gates depend on floating metal seats equipped with Hycar "O" rings to provide lubrication-free operation to or from any position with maximum resistance to hydrostatic pressure.

The Hycar "O" rings are in constant contact with both gate faces. They squeegee and polish the faces during valve operation, both to strip foreign material from gate and to assure a bubble-tight seal.

The manufacturer reports, "In thousands of valves in service over many years, Hycar "O" rings have proved their ability to 'take it' under most severe pipeline conditions".

Hycar offers exceptional resistance to change in properties, as well as resistance to abrasion, or corrosion from gas and oil. It will not swell and interfere with valve operation. Hycar is the choice for many tough oil field jobs. Get more information by writing Dept. KG-1, B.F.Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.



Seal-O-Ring gate valves are made by Grove Valve & Regulator Company, Oakland 8, California. Hycar "O" rings are used as packing and at valve seats. B. F. Goodrich Chemical Company supplies the Hycar nitrile rubber only.

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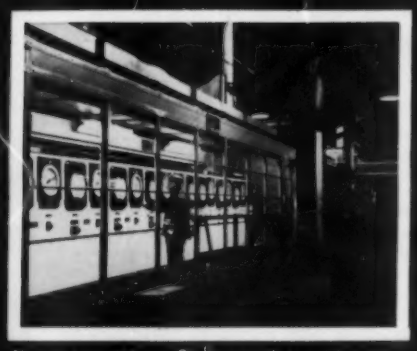

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For more information, turn to Reader Service card, circle No. 480

MATERIALS AT WORK

...AT A GLANCE

Wear problem solved with 17-4PH stainless

A serious wear problem in the design of a rotor for a two-stage colloid mill has been solved by the use of a 17-4PH stainless steel ring. The rotor, previously made entirely of type 303 stainless, offered satisfactory corrosion resistance, but lacked sufficient wear resistance to prevent damage at the edge where extremely high pressures exist. Insertion of a 17-4PH wear ring has substantially reduced the frequency of rotor replacement.

Source: Armco Steel Corp.; rotor manufactured by Manton-Gaulin Mfg. Co., Inc.

World's heaviest door made of concrete

An 85-ton, solid concrete block measuring 13½ ft high, 18 ft wide and 5 ft thick is being used for what is said to be one of the world's largest mobile door units. The door, which seals off a 24-million volt betatron, rides along the same track used to place test samples in the betatron room and can be closed in less than 1 min. The betatron is used for x-ray examination of metal castings weighing up to 50 tons.

Source: Allis Chalmers Mfg. Co.; betatron used by Mesta Machine Co.

Lead zirconate-titanate for stereo pickup

Stereophonic hi-fi enthusiasts can thank two lead zirconate-titanate elements for the quality of sound they are getting from their new stereo disks. The two lead zirconate-titanate elements, which are attached to a single stylus, transform mechanical energy (vibration) into electrical energy (sound) through the phenomenon of piezoelectricity. Lead zirconate-titanate was selected in preference to other piezoelectric materials (such as barium titanate) because it offers a higher ratio of electrical output to mechanical input and a lower modulus of elasticity.

Source: Lead Industries Assn.; materials supplied by Clevite Corp.

Nylon makes best bearing retainer

The switch from phenolic to oil-impregnated sintered nylon has solved the problem of excessive oil mass shifts in ball bearing retainers used in gyros in inertial guidance systems. The phenolic retainers previously used had an effective operating cycle of less than 200 hr; the nylon retainers have thus far been operating for more than 5000 hr with no indication of failure. Reasons given for the superiority of nylon: it holds sufficient lubricant in its pores to operate the bearing at high speeds for long periods, and the oil is distributed evenly.

Source: Barden Corp.

Nickel-cadmium batteries last longer

Nickel-cadmium batteries have replaced conventional lead-acid batteries in many commercial airplanes—at a saving of over $50,000 per year. The batteries, said to produce enough power to crank six engines without a generator assist, are substantially lighter and smaller and are claimed to outlast conventional batteries by several years.

Source: International Nickel Co.; batteries manufactured by Sonotone Corp.; used in Capital Airlines Vickers' Viscounts.

Phenolic replaces metal for pump parts

Molded phenolic has replaced die cast metal for the housing, valve and four other parts of a new hand pump used to dispense petroleum products. Primary

(continued on p 9)

Briefs

Aluminum rafts that can be manually erected in 15 min have been developed by the U. S. Army. The rafts, capable of carrying 12 tons of combat vehicles across rivers and streams in currents as swift as 8 fps, are fabricated from two 650-lb half-pontoons.

Striped polyethylene film is now available for packaging. The stripes, which are extruded-in, can be made translucent or transparent, wide or narrow, embossed or smooth.

Colored zirconium can be made by anodizing. A great variety of colors, including blue, gold, violet and green, can be obtained by varying the thickness of the tenacious oxide film.

Paper sandbags which could, if necessary, replace the standard jute sandbag with no loss in quality, have been developed by the Army. Currently, 26,000 knitted paper sandbags are being tested at various locations throughout the country.

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reason given for the change is the elimination of many finishing and assembly operations: the phenolic parts are held together with a simple cadmium-plated, snap-on clamp. Other advantages listed for the phenolic parts: dimensional stability, flexural strength, corrosion and chemical resistance, and light weight.

Source: Durez Plastics Div., Hooker Chemical Corp.; pumps manufactured by Tokheim Corp.; molded by Wayne Plastics Corp.

Carbide dies superior to steel

Tungsten carbide has proved more efficient than steel for compacting dies used in the production of aluminum oxide grinding wheels. The use of the carbide not only increased die life by as much as 75%, but allowed production to be increased by about 50%. Before adopting the carbide dies, a split steel die in a tapered case was tried but it was found to be no better than the original steel die.

Source: Kennametal, Inc.; die manufacturer: L&H Die & Tool Co.; grinding wheels manufactured by Mounted Points Co., Inc.

Flexible nylon tube may replace oil tanker

A flexible, sausage-shaped barge made of woven nylon coated with a synthetic rubber may become the oil tanker of the future. The barge, which is capable of resisting gasoline or fuel oil on the inside and sea water on the outside, is designed to be towed by a tug, emptied and then rolled up like a hose. The largest presently available barge has a capacity of 40 tons and measures 100 ft long and 5 ft in dia. Ultimately, barges are expected to have 10,000-ton capacities.

Source: British Information Services.

Hose couplings use AM-355 stainless steel

A relatively new stainless steel, AM-355, is now being used for couplings on flexible fuel and hydraulic lines in missiles and jet aircraft. The couplings, which are re-usable and have a special self-energizing metal-to-metal seal, are designed to withstand 1500 psi at 500 F. AM-355 was selected because it provides a combination of strength, toughness, ductility and corrosion resistance.

Source: Allegheny Ludlum Steel Corp.; coupling manufactured by Resistoflex Corp.

Titanium used in smallest tubing ever made

What is said to be the smallest metal tubing ever produced is being made of titanium for use as a casing for control wires in atomic reactors. The tubing, of the flexible, interlocking type, has a 0.050-in. i.d. and a 0.115-in. o.d. It was formed from a 0.010-in. thick strip of pure titanium. Titanium was specified despite fabrication difficulties because of its toughness, high heat resistance and low absorption of radioactivity.

Source: Flexonics Corp.

(more Materials at Work on next page)

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MATERIALS AT WORK

Edited by
Walter Lubars

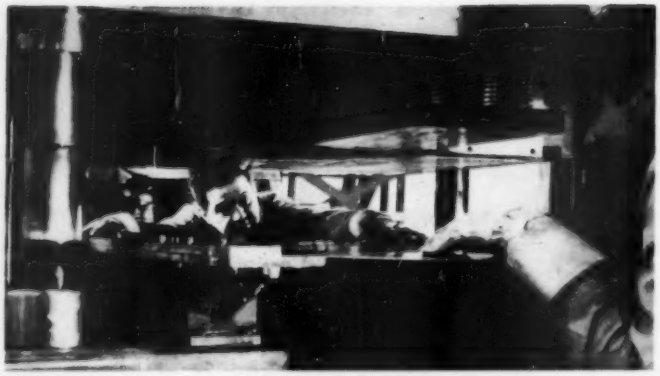
Precise tolerances held on giant magnets

The magnet core shown in the photo above is said to have been fabricated to "what are probably the most precise specifications ever drawn up."

The magnets, ranging in length from 75 to 90 in. and weighing as much as 15 tons, consist of thin laminations (0.031 in. thick) of high grade electrical steel. The largest contain as many as 2800 laminations. Tolerances allowed on the finished magnets are a maximum of $\pm 1/16$ in. in overall length and ± 0.002 in. on the contour of the pole tips.

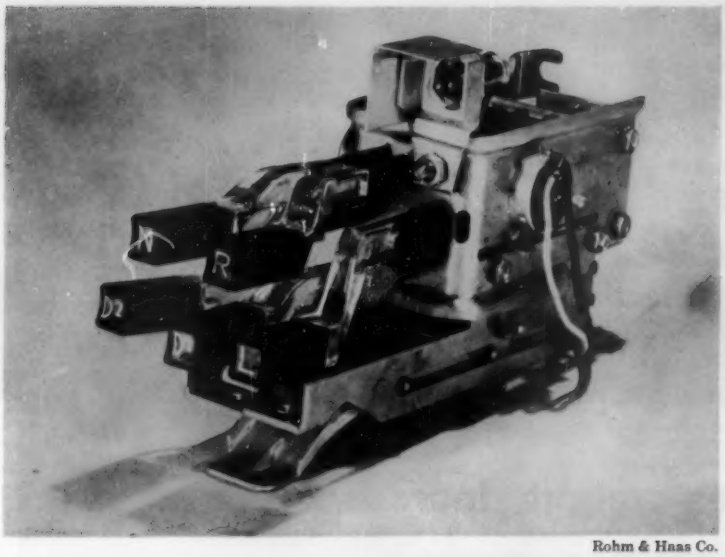
To make the magnets, sheets are first shuffled (to compensate for variations in magnetic characteristics) and then fed into a double-die press. After a double stamping operation, the laminations are stacked on a special fixture and a 1-in. thick end plate is placed on top. In order to decrease air spaces between laminations, and thus improve magnetic properties, the stack is placed in a press under 80 tons of pressure and tied with eight heavy steel straps welded along its sides.

The huge magnets are being built by Eddystone Div., Baldwin-Lima-Hamilton Corp., for use in the world's largest atom smasher at the Brookhaven National Laboratory. In all, 246 cores will be arranged end to end in a building ½ mile in circumference.



Laminations are punched in double-die press and . . .

. . . stacked in fixture where end plate is attached.



Rohm & Haas Co.

Molded acrylic pushbuttons *are used in automatic transmissions because . . .*

. . . excellent light transmission *provides good illumination.*

Acrylic pushbuttons for automatic shift

Molded acrylic has been specified for pushbuttons used in the new Rambler automatic transmissions. Reasons: acrylic offers excellent light transmitting properties and good impact strength, scratch resistance and surface finish.

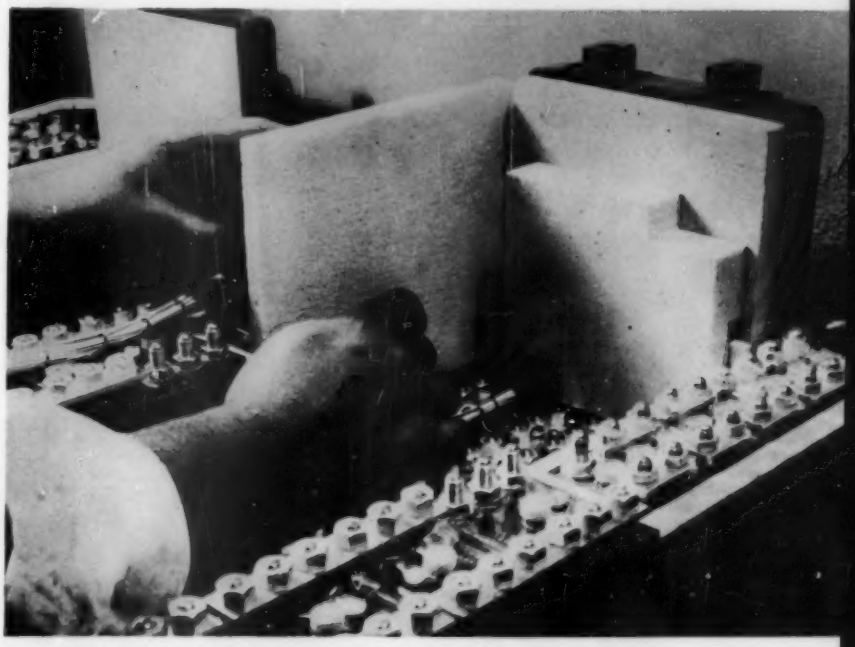
The five selector buttons, which vary in length from 3 to 4 in., consist of clear transparent cores with black sleeves forced around the visible ends. The forward end of all buttons is square in cross section and measures 0.355 in. on a side; the back sections are molded with different contours, tapers and curvatures to provide the necessary clearance when buttons are attached to the closely-clustered actuator arm of the selector mechanism. Molded-in notches simplify installation of the buttons; by attaching to prongs on the actuator arm, they avoid the need for mechanical fasteners.

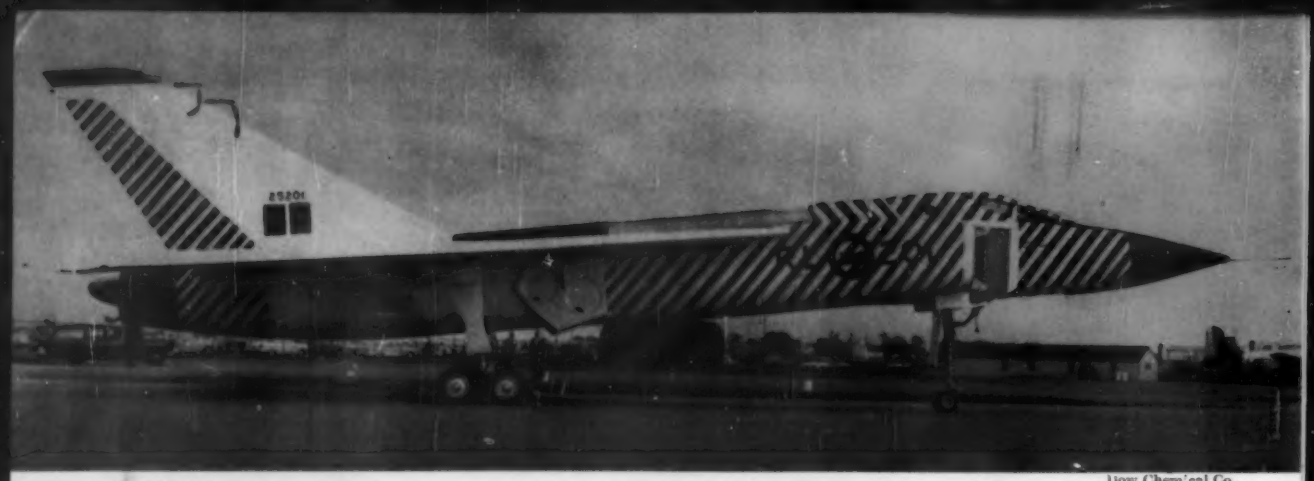
Machined urethane foam is best battery spacer

Urethane foam has replaced cellular cellulose acetate for the spacers used in Yardney Electric Corp.'s silver-zinc batteries (see photo at right).

According to Allied Chemical Corp., the cellular cellulose acetate spacers were found to be too compressible and too weak to prevent cell shifting. In addition, they had a tendency to break at points of stress after machining to shape. A rubber-plastic foam was also tried, but proved unsatisfactory.

Reasons given for the selection of urethane: light weight (density is 17 to 21 lb per cu ft), good electrical characteristics, excellent machinability (they can be machined to tolerances of ± ⅛ in.), ability to withstand high stresses, and resistance to potassium hydroxide and flame.

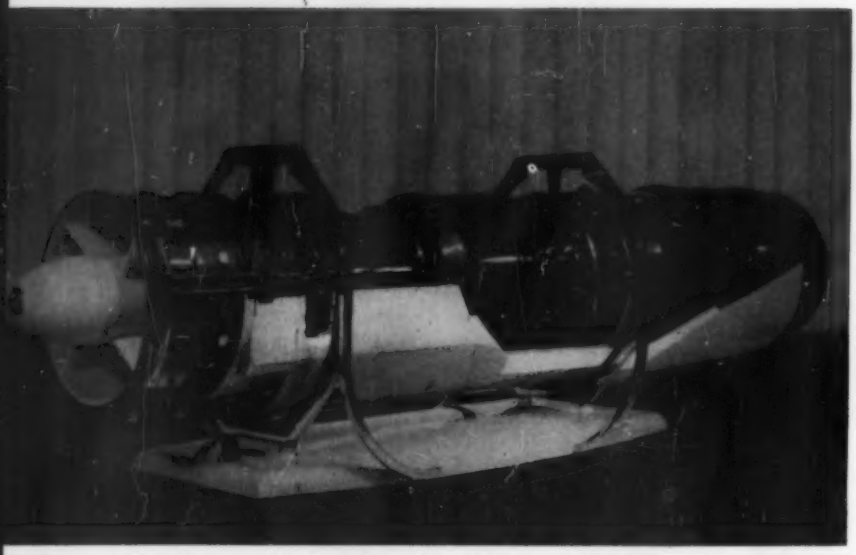




Sheet *is used for a substantial percentage of fuselage skin (striped areas).*

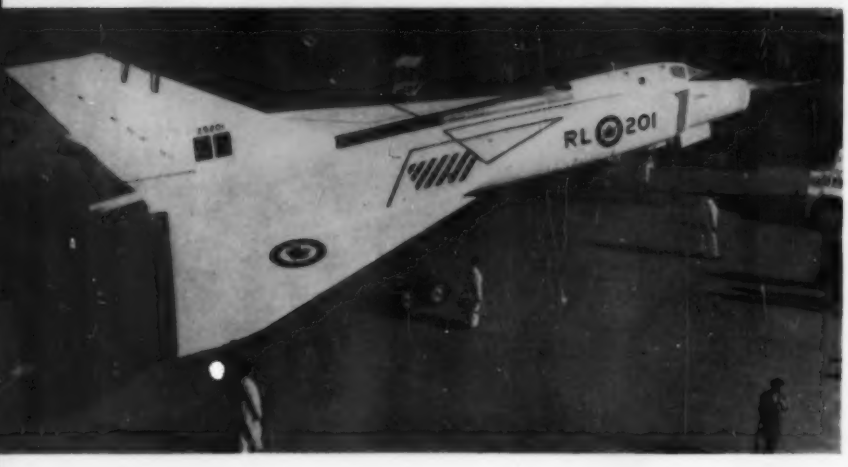
Dow Chemical Co.

Magnesium reduces weight, increases power of jet



Castings *ranging from less than 1 lb to over 100 lb are used in engine.*

Plate *of magnesium-thorium is used under wing (striped areas).*



Extensive use of magnesium in the airframe and power plant of Canada's new CF-105 "Arrow" fighter plane is said to have resulted in an "unprecedented power-weight ratio." According to Avro Aircraft Ltd., each of the plane's two engines turns out over 20,000 lb of thrust, resulting in a ratio of 5 lb of thrust for each pound of weight.

Three different forms of magnesium are used in the new plane: 1) magnesium alloy sheet is used for a substantial percentage of the fighter's fuselage skin; 2) machined magnesium-thorium plate (HK31A) is used on the underside of each wing in areas where built-up fabrication is impractical; and 3) magnesium castings ranging from less than 1 lb to over 100 lb are used in the engines. Total magnesium weight in the airframe exceeds 500 lb.

To fabricate most of the magnesium airframe skins, moderate two or four-directional forming was required. To accomplish this, Avro turned to a novel vacuum forming technique closely related to metal-to-

(continued on p 162)

MORE MATERIALS AT WORK

Aluminum moon house may have to float 162

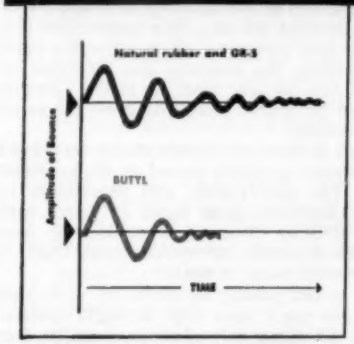
Melamine housings cut cost of photocopier 164

Zinc die casting replaces cast iron 166

Plastics 'copter blades protected with steel..... 168

Precise mica spacers protect electron tubes 170

BEST WAY TO ABSORB SHOCK!



Butyl's superior shock absorption characteristics reduce amplitude of bounce in much less time as compared with other rubbers.

Enjay Butyl, because of its higher damping factor, absorbs shock energy *more* completely than any other rubber. Through simple variations in compounding or processing, you can build the right degree of resiliency for your requirements. Butyl is the ideal rubber for motor mounts, load cushions, sound deadener insulation, axle and body bumpers—and other shock, noise and mechanical vibration applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . heat . . . abrasion, tear and flexing . . . unmatched electrical properties and impermeability to gases and moisture.

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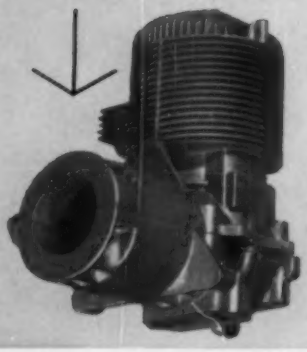
FROM
camera parts

TO
engine cylinders



ADVANCE designs and produces zinc and aluminum die casting components for manufacturers from coast-to-coast.

Whatever your zinc or aluminum die casting needs may be, ADVANCE has the creative engineering and production skill that improve product parts and lower costs.

It can pay you to write ADVANCE for a survey and cost estimate on that next die cast part.

These symbols are your assurance of highest quality control of zinc and aluminum alloys under ADCI standards.

38 years of service to industry.

ADVANCE
TOOL AND DIE CASTING CO.
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Milwaukee 12, Wisconsin

For more information, turn to Reader Service card, circle No. 407

Standards guides

To the Editor:

We have read with a great deal of interest the series of articles on standards and specifications in recent issues of M/DE. This series is an excellent explanation of the various types of standards.

Will you please send us four copies of this series?

J. L. SCHULER
Dept. of the Navy
Bureau of Ships
Washington 25, D. C.

This series of six articles, published May through August of last year, is available in one bound reprint and has been forwarded. Prices are 75¢ each for 9 copies or less, 60¢ each for 10 or more.

Nonmetallic mold materials

To the Editor:

In one of your issues, probably within the last two years, I noticed reference to a nonmetallic material suitable for foundry molds. I'm not sure if it was sprayed, cast or molded, but it was a nonmetallic which resisted not only elevated temperatures but also the corrosive effects of molten metals. Can you help on this?

HAROLD P. CONROY
Goleta, Calif.

Articles on the Shaw and Investment X casting processes have been forwarded. These processes use ceramic molds. Information on the Glascast process has also been sent.

Hard = brittle?

To the Editor:

We are taught that the modulus of elasticity of steel is always 29-30 x 10^6 psi. This means that if a certain steel or heat treatment offers twice the yield strength of another, the material has stretched or bent twice as far by the time it yields. Double strength divided by double deflection gives the same modulus of elasticity.

The concept of hard but brittle steels—and hard but brittle tempers—is firmly rooted in the practical man's beliefs. The universality and persistence of the idea that hardness goes hand in hand with brittleness is striking. Because it is held by men who learned about metals by working with them, it must have a strong basis in reality.

Hardness is not exactly synonymous with high strength, but you can't have high strength without high hardness. Speaking only of steels, I realize that as-quenched steels, though hard and strong, have localized regions of high stress due to quenching. These locked-in stresses make the parts easy to frac-

"B&W Welded Stainless Steel Tubing resists corrosion because it is fully annealed and precision made

As a design engineer working with heat exchanger and condenser applications, I know the importance of selecting tubing that's fully annealed. That's why I choose B&W Welded Stainless Steel Tubing. It gives me resistance to corrosion, ease of fabrication and close tolerances that I want."

B&W's production practice of fully annealing all welded stainless steel heat exchanger and condenser tubing and performing a minimum amount of cold work after heat treatment achieves the ideal condition of maximum general corrosion resistance and close size tolerances. This provides ease of fabrication and threading of tubing through baffles and tube sheets and minimizes the possibility of failures in service due to combinations of stress and corrosion.

For further information, call Mr. Tubes, your nearest B&W representative—he can help you solve any tubing problem—or write for Bulletin TB-415. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

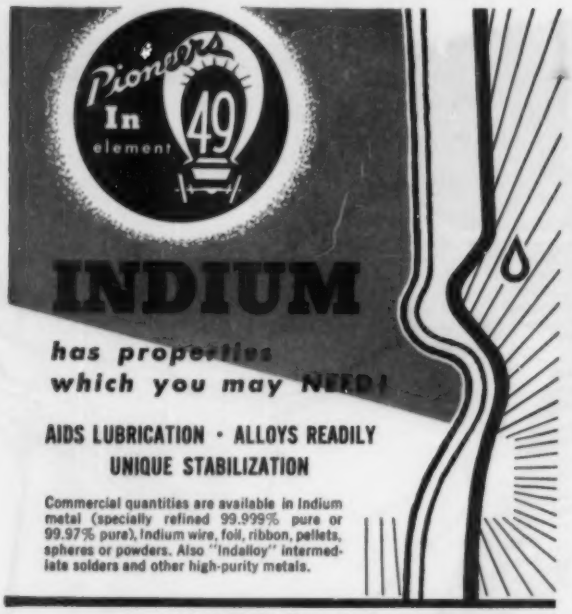
B&W
TUBULAR PRODUCTS DIVISION

TA-9007-PG-2

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

For more information, turn to Reader Service card, circle No. 415

For more information, turn to Reader Service card, circle No. 367


Pioneers
In
element
49
INDIUM
has properties
which you may NEED!
AIDS LUBRICATION • ALLOYS READILY
UNIQUE STABILIZATION
Commercial quantities are available in Indium metal (specially refined 99.999% pure or 99.97% pure), Indium wire, foil, ribbon, pellets, spheres or powders. Also "indalloy" intermediate solders and other high-purity metals.

Write Dept. M-1 for new Indium bulletin:
"Determination of Arsenic in Indium Arsenic Alloys."

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For more information, turn to Reader Service card, circle No. 429

ture, hence brittle. That somehow doesn't seem enough of an explanation for the hard-equals-brittle idea. Surely steels are not *generally* used with inadequate tempering.

I wonder if your readers have any other explanations for this apparent conflict of ideas.

JAMES D. THACKREY
Chief Research Engineer
Avildsen Tools & Machines, Inc.
Glendora, Calif.

We would like to hear from them if they do.

Thermoelectric ceramics

To the Editor:

On p 4 of the Oct '58 issue you say enough about ceramic thermoelectric materials to get me interested and so little as to leave me frustrated. Can you tell me more—preferably with names and addresses so I can get in touch with the developers directly?

H. BANDES
Arthur D. Little, Inc.
Cambridge 40, Mass.

More information was published in the Nov issue, p 158. Source of the story is Westinghouse Electric Corp., Box 3278, Pittsburgh, Pa.

Prizes for Your Letters

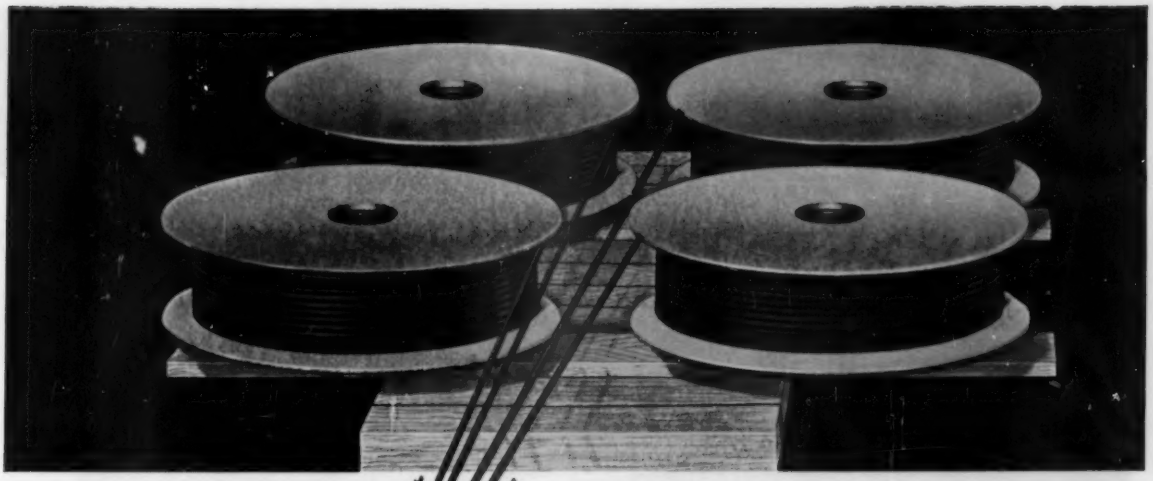
Last month we announced a new—and continuing—contest that will give you a chance to sound off and get paid for it. In case you missed this announcement, we repeat the details here.

A check for $10 will be yours if you write a letter that, in the editors' opinion, is the best published in any given issue. Letters may concern M/DE, the field of materials selection and use, or the engineering profession in general.

For example, letters may compliment us, criticize us, or offer suggestions. They may deal with your personal experiences, gripes or controversial ideas in connection with materials problems or professional aspects of engineering.

Send your letters to: Letters to the Editor, MATERIALS IN DESIGN ENGINEERING, 430 Park Ave., New York 22, N. Y. Letters addressed to individual authors or editors will automatically receive consideration.

Letters received by the 28th of any month will be considered for the issue dated two months later. Thus, letters received by Jan 28 will be published in March or later. Judgment of the editors is final, and we reserve the right to withhold awards.



WOLVERINE LONG LENGTH COILS ARE LONG ON SAVINGS

Manufacturing refrigerators, air conditioning units or, for that matter, anything requiring copper tubing?

If you are you can save time, money and space simply by specifying Wolverine Tube's long length bunch or level wound coils.

Level wound coils are ideal for continuous feeding of automatic equipment. (For example, the illustration in this advertisement, shows the quantity production of return bends.) Level wound coils permit high speed unwinding without the danger of the tubing becoming snarled or tangled. They often eliminate the necessity of standby operators. Both level wound and bunch coils provide greater inventory flexibility resulting in production economies as well as substantial savings in floor space requirements.

Why not get complete information about savings made possible by these Wolverine products! This advertisement attached to your letterhead will bring competent counsel from Wolverine. Mail it—TODAY!

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

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WOLVERINE TUBE
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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES
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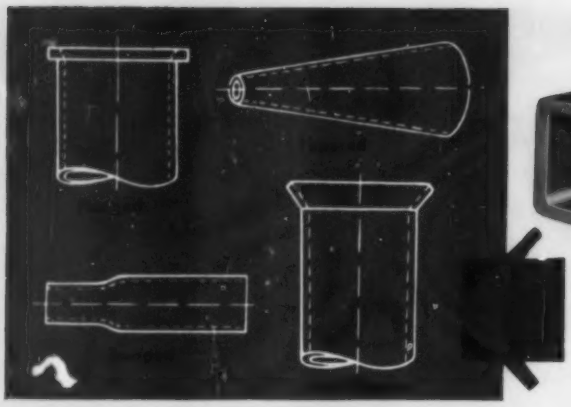
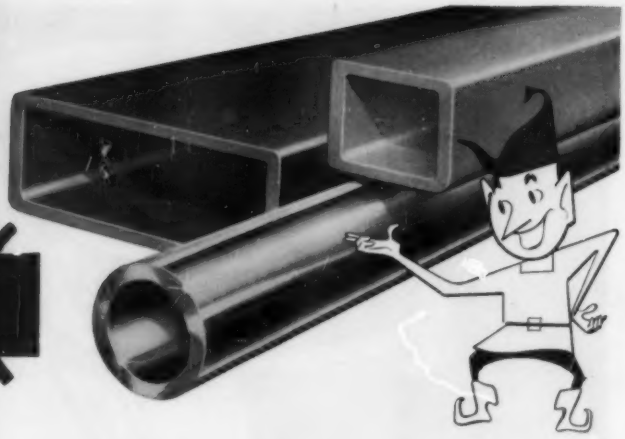
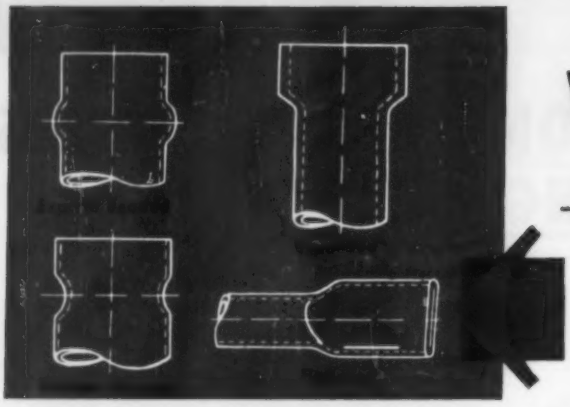
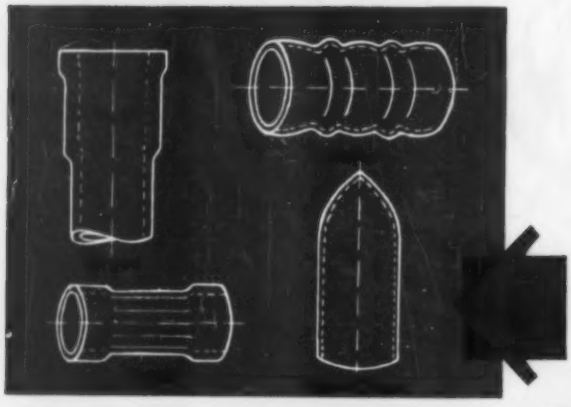
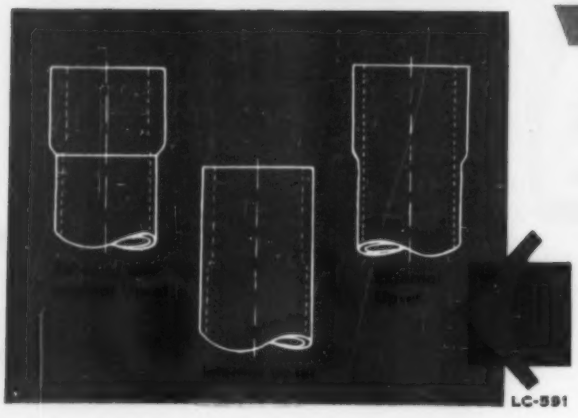
For more information, turn to Reader Service card, circle No. 371











LC-591

WELDED TUBING

fabricates

every way

Welded steel tubing fabricates readily by all methods because of its inherent properties and uniformity of dimension and wall thickness.

Shown at left are some basic tube fabricating possibilities, and welded steel tubing fits them all. It is readily machinable, joins by literally every known method, and is available in all weldable grades of carbon, stainless steel and other alloys in round and special shapes.

When it's tubing you need—specify *welded* steel tubing from one of the quality tube producers.

WRITE for Bulletin 8591 "Welded Steel Tubing."

FORMED STEEL TUBE (FSTI) STEEL

TUBE INSTITUTE, INC.

850 HANNA BUILDING
CLEVELAND 15, OHIO

• Armco Steel Corp. • The Babcock & Wilcox Co., Tubular Products Div. • The Carpenter Steel Co., Alloy Tube Div. • Clayton Mark & Co. • Damascus Tube Co. • Jones & Laughlin Steel Corp., Electricweld Tube Div. • National Tube Div., United States Steel Corp. • Ohio Seamless Tube Div. of Copperweld Steel Co. • Republic Steel Corp., Steel and Tubes Div. • Revere Copper and Brass Inc., Rome Manufacturing Company Div. • Sawhill Tubular Products, Inc. • Southeastern Metals Co. • The Standard Tube Co. • Standard Tube and T. I. Ltd., (Canada) • Superior Tube Co. • Trent Tube Co., Subs. Crucible Steel Co. of America

GRAPHITAR® (CARBON-GRAPHITE) and GRAMIX® (PRODUCTS OF POWDER METALLURGY)

bearings in Leland submersible motor unit operate with gasoline as the only lubricant

238

Running directly in gasoline, this superbly-designed Leland submersible motor embodies two GRAMIX thrust washers and two GRAPHITAR bearings to keep the operation of this amazing explosion-proof pump motor safe and smooth.

Thirty years ago the manufacturer of these pumps—the Leland Electric Co., Dayton, Ohio, a division of American Machine and Foundry Co., developed the first gasoline curb-pump motor to receive Underwriters' Laboratories' approval. Throughout their long experience, they have selected every component with great care. It is thus significant that for Leland's submersible motor they selected GRAPHITAR and GRAMIX bearings.

GRAPHITAR is a non-metallic, carbon-graphite material that will not weld or score even when in contact with a metal shaft. Any liquid will act as a lubricant, thereby reducing friction and increasing service life. With low-viscosity liquids such as gasoline, friction is at a minimum because of the low film strength.

GRAMIX, tough, long-wearing sintered-metal, has an extremely high particle hardness and excellent surface finish; can be precision die-pressed to tolerances within .0005". GRAMIX parts can withstand incredible amounts of pounding action. These factors, coupled with their extremely low cost, have helped add to the increasing use of GRAMIX parts in many industries.

Write today for these two new engineering bulletins GRAPHITAR Bulletin No. 20, and GRAMIX Bulletin No. 21.

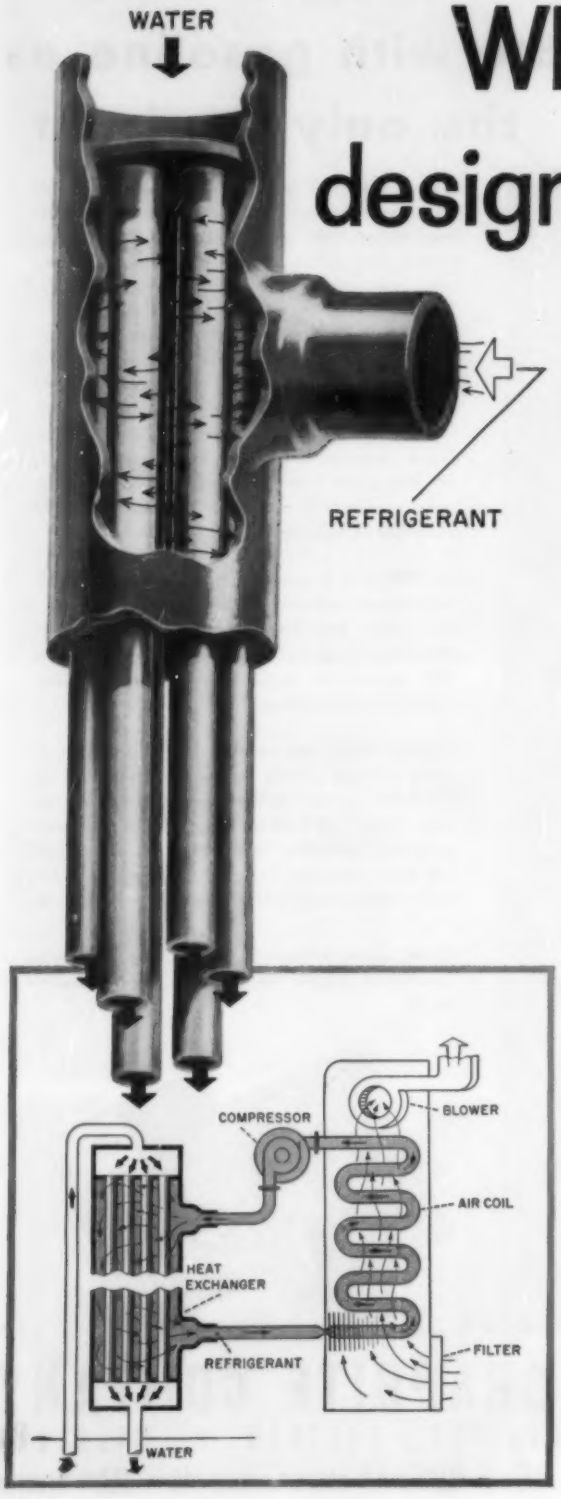
THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

REPORT ON THE COPPER METALS:

What are today's design possibilities?



Design possibilities with the copper metals are as varied as these metals themselves. The forty-two industry standard alloys and the hundreds of special copper alloys offer combinations of electrical, thermal, chemical, structural, joining and finishing properties which are more valuable in this day of rigid performance specifications than ever before.

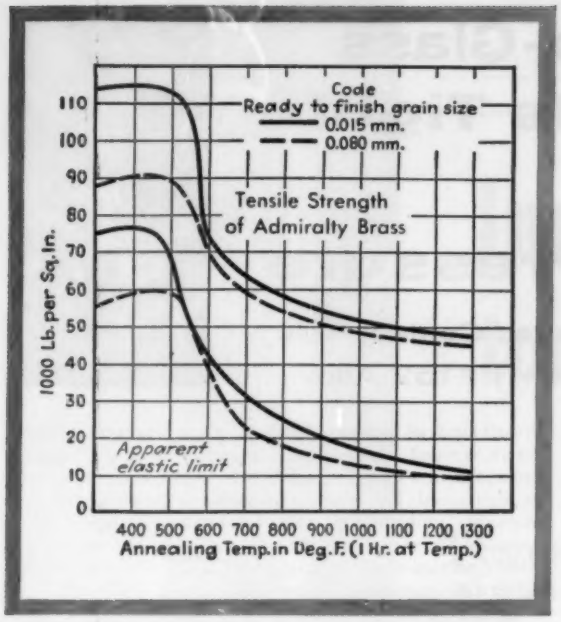
Today, most parts must meet several material requirements. Even a fastener, in addition to strength, may need corrosion resistant and high-finish properties. A supporting member may also have to conduct heat. Efficiency calls for materials versatility. And versatility calls for the copper metals. Although used since 7500 BC, copper is being re-examined as a new material with design possibilities that have scarcely been tapped. Here are some of the problems, and some of the properties that have special meaning at this time:

Design Problem — Heat pump condenser

The tube-in-tube condenser in a Typhoon Heat Pump must transfer heat between the ground water and the recirculating refrigerant. Corrosive sodium and sulphur compounds are dissolved in the ground water. The refrigerant, being highly volatile, must be confined in a leakproof system. The house air must be heated in winter and cooled in summer by passing over heat-transfer coils. The design requirements, then, include corrosion resistance, heat conductance and impermeability to the refrigerant. These requirements are met by three forms of copper. The ground water is contained in Admiralty Brass because of its excellent resistance to salt and sulphur corrosion. The refrigerant is contained in commercially-pure copper because of its density and the impermeability of its soldered joints. The air coil is a tinned copper fin soldered to a copper tube for maximum heat transfer at a realistic cost.

The good heat conductivity of copper and Admiralty Brass is, of course, important. But the conductivity of the metals themselves would be of little use if they did not also resist corrosion. The reason for this (besides durability) is because a heavy layer of corrosion products would severely reduce transfer efficiency.

TYPHOON HEAT PUMP CONDENSER SECTION (shown actual size). Heat exchange between ground water and refrigerant is accomplished in this unit. The corrosion resistance and high heat conductance of the copper metals used are vital to efficient operation. Drawing at bottom shows the complete cycles schematically.



EFFECT OF ANNEALING ON TENSILE STRENGTH and apparent elastic limit of admiralty-metal strip, previously cold-rolled 6 B. & S Nos. (50% reduction of area) from two different grain sizes, 0.015 and 0.080 mm. (0.040-in. stock).

As with any piping system, impact and tensile strengths of the groundwater tubing are also important. Slight shifts in the substrata can produce heavy stresses. Admiralty Brass, as manufactured for this tubing, develops a tensile strength of the order of 45,000 psi. Many copper alloys are even stronger. The high-zinc brasses, nickel silvers, beryllium copper, the silicon bronzes and the phosphor bronzes can be processed to provide tensile strengths of the order of 140,000 psi for hard-drawn wire. Strengths, of course, vary with temper. The graph above illustrates the range of strengths for Admiralty Brass.

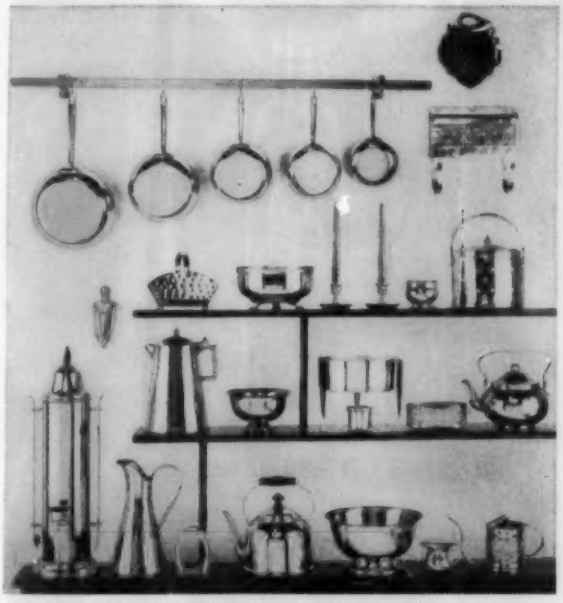
Design Problem — Preheating for atomic reactor

The induction heating coils used in the Organic Moderated Reactor Experiment, a nuclear power project operated by Atomics International, a division of North American Aviation, Inc., for the Atomic Energy Commission, keep the organic moderating compound in a fluid state during reactor startup and shutdown. The necessary high temperatures are generated by eddy currents in the reactor tank. The design requirements for the coils were high electrical conductivity and good high-temperature characteristics. Oxygen-free, high-conductivity copper was the answer. Its freedom from impurities assures high conductivity and guards against high temperature oxidation and scaling.

Design Problem—Yours

The combination of properties that you need for today's multifunction design requirements can probably be found among the copper metals. The copper industry will help you find it. The Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y., will welcome your inquiry.

COPPER COILS being installed on the bottom of the main core vessel of the Organic Moderated Reactor Experiment.



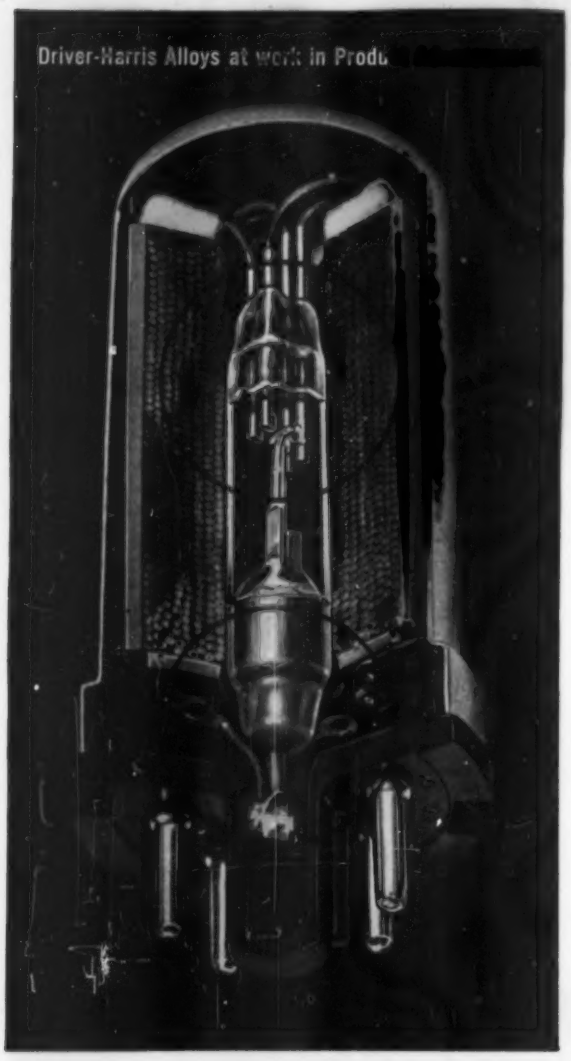
FINISHING REQUIREMENTS. The nickel silvers and low-zinc brasses are widely used in ornamental applications because of their ease of plating and finishing as well as their cold-working properties. The new fine-grain brasses offer an ideal surface structure for economical high finish.

The picture above shows various combinations of coppers and brasses used decoratively in housewares.

For more information, turn to Reader Service Card, circle No. 395

Improved Metal-To-Glass Alloy Holds Seals Tight Against Hydrogen at 250 Pounds Pressure

Development of Clare† Mercury-Wetted Contact Relays aided by special gas-free Driver-Harris #152 Alloy



For all kinds of high-speed switching machines and devices which demand accuracy and dependability of the highest order, this new Clare Type HG Relay offers a combination of high speed, high current-and-voltage capacity with remarkably uniform long-life performance. It has a conservative life expectancy of more than a *billion operations* when operated within its ratings and can be driven at speeds up to *100 operations per second.*

In this cutaway view (2¾ x) a magnetic switch, hermetically sealed in a high-pressure hydrogen filled glass capsule, and a coil, are enclosed in a steel vacuum tube type envelope. The switch forms the core of the coil which provides the magnetomotive force for operating it.

The glass enclosed switch is very compact and small (5/16" diameter x 2" long) yet its handling capacities of 5 amperes and 500 volts maximum are truly remarkable.

These features of its construction make this possible. In the switch segment, the platinum contact surfaces are wetted and protected from electrical and mechanical erosion with mercury by means of a capillary connection to a mercury reservoir below the contacts. In addition, the high hydrogen pressure enables the contact gap to withstand a high voltage gradient without breakdown.

Keeping the gas from leaking posed a production problem. The specifications for the lead wires at the top of the switch and the tubular vacuum stem at the bottom were stiff. 1. Gas-tight seal against hydrogen at 250 PSI. This was difficult. 2. Perfect match to thermal expansion characteristics of the glass. 3. Good ferromagnetic properties. 4. Exceptional surface bonding properties since the permissible maximum 5 ampere 500 volt limits are dictated rather by factors relating to heating of the metal-to-glass seal than the current handling capacities of the contacts.

Driver-Harris was called upon to produce such an alloy and succeeded in developing a special gas-free nickel-iron alloy No. 152 which meets all these requirements to the complete satisfaction of Clare Engineers.

Do your engineering and product development plans hinge upon a special alloy — why not discuss it with Driver-Harris. We have, since 1899, produced 132 special purpose alloys in just this fashion — in answer to a particular problem and extraordinary specifications. We have a special bulletin on Sealing Alloys if you care to have one. Your inquiry is awaited.

†C. P. Clare & Co., Chicago, Ill.
*T.M. Reg. U.S. Pat. Off.

DRIVER-HARRIS* COMPANY

HARRISON, NEW JERSEY • BRANCHES: Chicago, Detroit, Cleveland, Louisville

Distributor: ANGUS-CAMPBELL, INC., Los Angeles, San Francisco • In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

For more information, turn to Reader Service card, circle No. 435

An announcement of interest to manufacturers of steel parts

Improvements in today's STRESSPROOF STEEL BARS WITH COPPER

1 **100,000 PSI YIELD STRENGTH** in all sizes . . . without heat treating.

2 **IMPROVED PHYSICAL PROPERTIES...** better fatigue life wearability, and resistance to atmospheric corrosion. Over-all quality is improved.

3 **IMPROVED MACHINABILITY...** STRESSPROOF with copper now machines faster and better than ever. It gives longer tool life, better finish, and more production from a day's run, according to shop production records.

4 **CLOSER TOLERANCES...** Tolerances for rounds have been tightened to meet the need for more precise parts as follows:

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5 **COMPARED WITH OTHER STEELS, STRESSPROOF COSTS EVEN LESS TODAY...** Also saves machining and heat treat costs, and you get a better quality part. It will pay you to take another look at this improved material.

Your STEEL SERVICE CENTER stocks contain today's STRESSPROOF. It has been produced and shipped over a several months' period.

JUST PUBLISHED! Use this coupon to request your copy of new bulletin, "Improvements in Today's STRESSPROOF Steel Bars."

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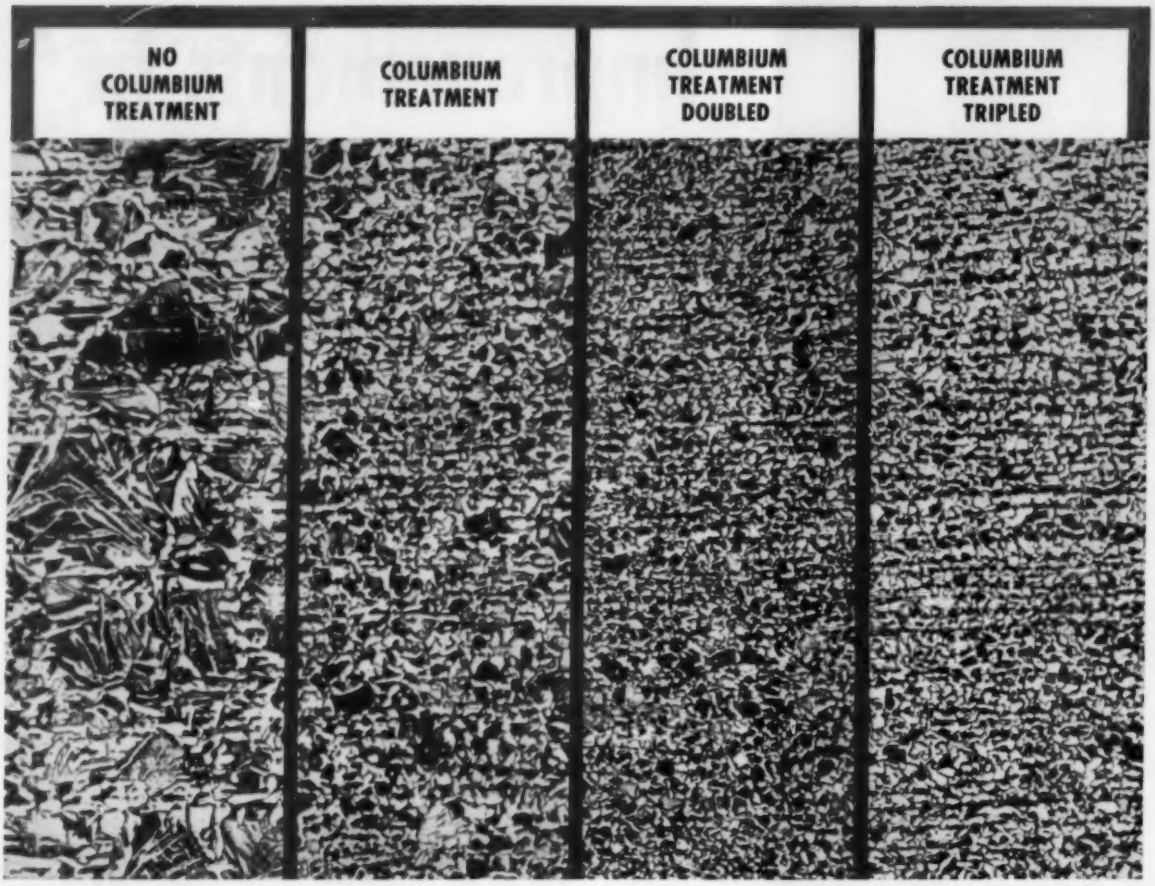

Composite of photomicrographs made from the same heat of mild carbon steel shows the effect of varying columbium treatments on the grain structure of the steel.

The Great Lakes Family of High-Strength Steels

N·A·X FINEGRAIN STEEL

Lets you design superior performance, longer life and less weight into your product. Many diversified applications.

N·A·X HIGH-TENSILE STEEL

Offers all the characteristic features of N-A-X Finegrain, plus greatly enhanced resistance to atmospheric corrosion.

GLX W

A series of fine grained, mild carbon steels. They have unusually high strength, toughness and weldability.

N·A·X N-A-XTRA STEELS

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STEEL CORPORATION'S NEW GLX-W STEELS GIVE ... HIGH STRENGTH TOUGHNESS REDUCED COSTS

Key to the success of Great Lakes' new GLX-W Series of steels is the fine grained internal structure produced by treatment with columbium. This grain refinement also contributes to ductility. And in addition, the GLX-W Series' low carbon and manganese content assures excellent weldability with freedom from underbead cracking under all conditions.

COST AND WEIGHT SAVINGS

Where design permits the replacement of carbon steel with GLX-W steels, weight savings of 20 to 35 per cent, and cost savings of 10 to 25 per cent can be realized. When replacing alloy steels the cost savings can range from 25 to 35 per cent. These steels feature higher yield strengths, greater tensile strengths and increased toughness without costly heat treatments or extensive alloy additions.

The GLX-W Series is so priced that substantial cost reductions can be obtained by weight reduction over mild carbon steel. Cost reduction can also be obtained over alloy steels because of the lower price of GLX-W steels.

MANY USES FOR GLX-W STEELS

GLX-W steels are especially recommended for a broad range of applications in mobile equipment and pressure vessels, as well as the transportation and construction fields.

STRONGER AND TOUGHER

GLX-W steels are stronger and tougher than ordinary mild carbon steels and in some applications can do the job now being done by the more costly alloy steels.

GLX
W

For additional technical information about these economical GLX-W steels write

Product Development Division, Dept. D-1
GREAT LAKES STEEL CORPORATION
Detroit 29, Michigan • Division of
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STAINLESS STEELS

The gleaming beauty, plus the permanence and ease of cleaning have made stainless steel the wife's delight—and sold many a home.

When made from Uniloy stainless steel, flatware, utensils, and other kitchen accessories have that inviting blend of beauty and permanence so appealing to the modern homemaker.

Uniloy stainless steels—easy to work and form—are rolled to most exacting specifications by steel makers who have been making specialty steels since 1884.

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MOTO-MOWER

FORMS SEAT and SHROUD

from

CYCOLAC® SHEET

HIGH-IMPACT THERMOPLASTIC RESIN

HERE'S WHAT CYCOLAC SHEET MEANS TO MOTO-MOWER

The Moto-Mower Division of Detroit Harvester Co. designed a colorful, comfort-molded seat and a light-weight, long-lasting shroud for its Moto-Mower Power Lawn Mower. Replacing costly, heavier metal in these particular applications, Cycolac was greatly responsible for the development of a lighter-in-weight power lawn mower . . . a more economical-to-manufacture, easier-to-sell unit, designed to take severe use and abuse in dependable stride.

Cycolac Sheet Extruded and Formed by:
Panelyte Division, St. Regis Paper Company, Richmond, Indiana

THIS IS CYCOLAC... AND WHAT IT CAN DO FOR YOU!

This family of single uniform resins is extremely tough and versatile; extrudes readily, in profiles and sheets; easily injection molded and post formed.

- Wide range of process properties
- Fast extrusion to accurate dimensions
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Write for technical literature today!

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SYNTHETIC RESINS

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BORG WARNER • Washington, West Va.

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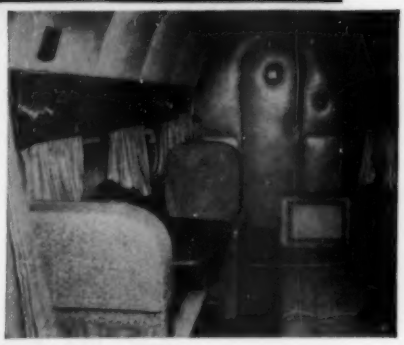
In these ways:

For relaxable cushioning, soft to the touch, yet not bouncy.



As insulation, padding, carpet underlay and seating.

Because of these advantages:

So tough it hog-rings to seating springs without backing support or fabric liners.

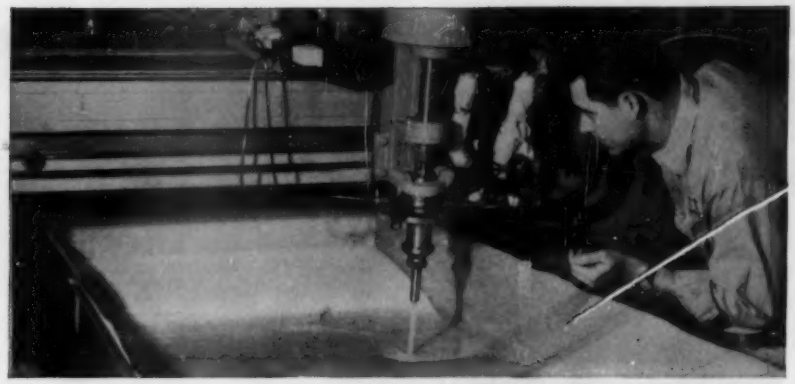
Elasticity, durability and structural strength unmatched by any other foam material.

... Plus Functional Utility...

In addition to the above uses, industry leaders are specifying urethane foam for sound and thermal insulation, underlay, footwear, sporting goods, household items, and dozens of other uses because it can be molded, heat-sealed, hot-wire or die-cut, flocked and colored; it's shock-absorbent, density-controllable, resistant to cleaning chemicals, soaps, fire, mildew, heat, cold, abrasion.

Space does not permit listing all of the advantages of urethane foam for the designer, fabricator, manufacturer and consumer. Some of the biggest names in the auto, aircraft and furniture industries call it "the unbeatable combination" for improving design, lowering costs and expanding markets. Write Mobay for the facts and learn why.

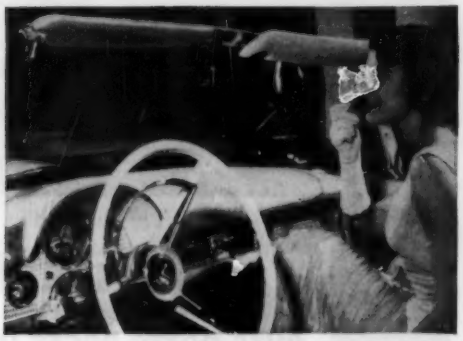
and more FOAM is being used



Mobay developed the first commercial "one-shot" foaming system, which greatly simplifies the production and curing cycle for polyether urethane foams—evidence of Mobay's technical leadership in the urethane industry.

As supple, lightweight interlining.

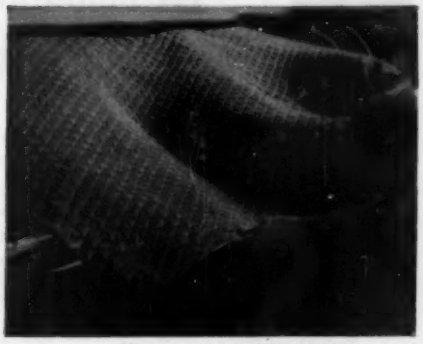
As economical protection for shipment and storage of precision equipment.



For molded safety dash panels and sunvisors, cushioning and seating.

So easy to fabricate, it cuts with ordinary scissors or power-driven pattern cutters.

Feather-light, shock resistant —a wide range of densities, resiliencies and toughness.



Slices so thin it has the drape and feel of velvet . . . quilts to fabrics with standard equipment.

Mobay is the leading supplier of urethane chemicals used in the manufacture of polyether and polyester foams, urethane elastomers and protective coatings.

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First in Urethane Chemistry

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Dept. MD-6
1815 Washington Road, Pittsburgh 34, Pa.

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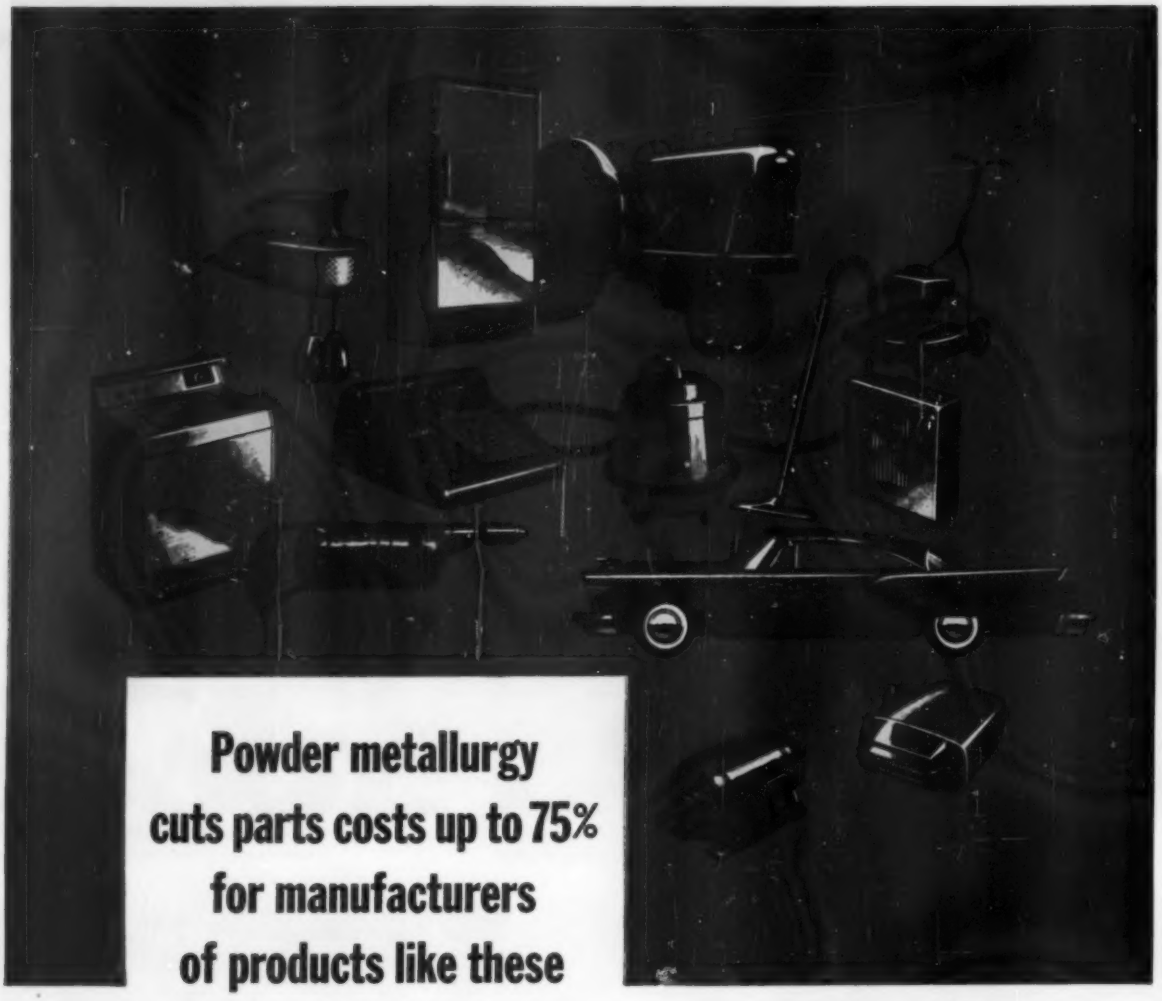
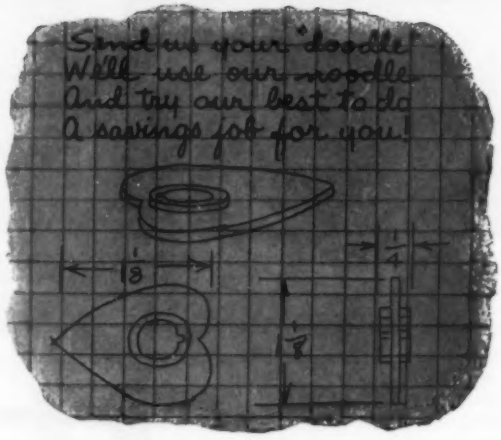


Powder metallurgy cuts parts costs up to 75% for manufacturers of products like these

Why not find out now if powder metallurgy holds the answer to your high parts costs?

Send Glidden a sketch of any part, plus the quantity desired. Glidden, with the help of qualified parts fabricators in your area, will determine, first, whether the part can be made with metal powder. If it can, you will receive cost quotations that may show really worthwhile savings—similar to savings realized by an increasing number of manufacturers who have found that metal powder parts can be mass-produced faster, better, more economically.

As a leading supplier of metal powders, Glidden works closely with parts producers. In this way, several staffs of experienced technicians may be at your disposal—to provide complete technical service and suggest possible design changes that may bring even lower parts costs.



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Chemicals—Pigments—Metals Division
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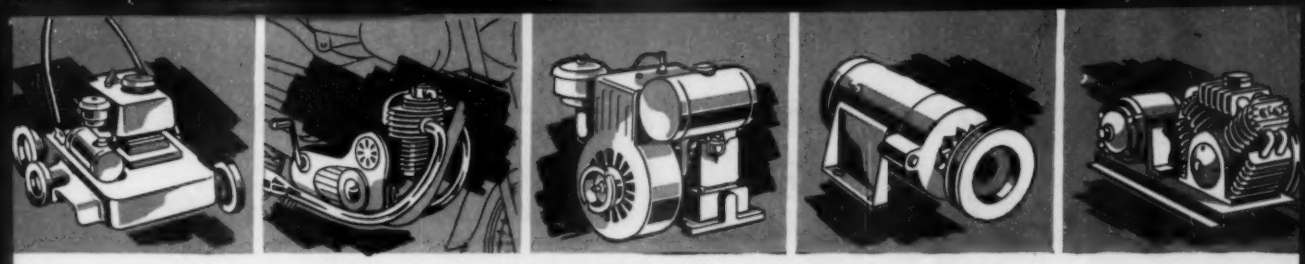

LIGHT, DURABLE ALUMINUM HELPS BUILD MODERN MOTORS

Whether you're mowing the lawn or motor boating, enjoying air conditioning or running a power saw, you are relying on motors—and *aluminum*. The power and efficiency of these mighty units help you perform many tasks better and faster, at considerable saving of energy.

The growing motor-building industry serves you and itself exceedingly well—through aluminum. Lightweight aluminum gives extra ease of handling to motor-equipped appliances, and its ability to resist rust, corrosion, pitting and chipping assures longer, trouble-free life. Aluminum contributes strength wherever it is used, reduces costs as it saves steps in the production process.

Apex Smelting works hand in hand with the builders of modern motors. Apex aluminum alloys, scientifically produced to each manufacturer's exacting requirements, are significant factors in the outstanding performance and quality you enjoy in today's motors.

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Producers of ALUMINUM, MAGNESIUM AND ZINC ALLOYS

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SPRINGFIELD, OREGON (National Metallurgical Corp.)

Research leadership back of every ingot

Your products may also be produced better and more efficiently with the help of aluminum castings. Apex Smelting and the companies it serves in the die casting and foundry industry stand ready to assist you and your engineers.

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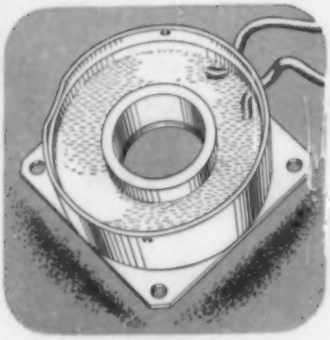
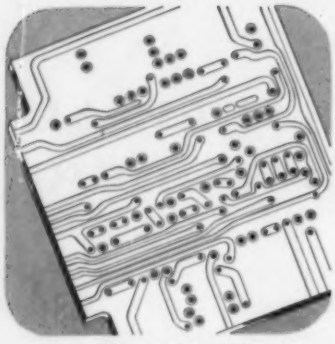
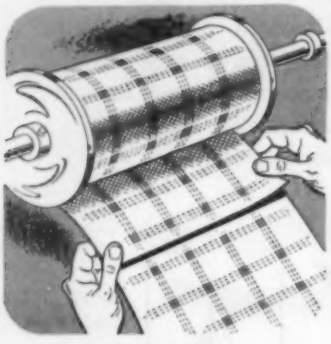
How you can cut time and costs with R/M *Ray-BOND* Adhesives



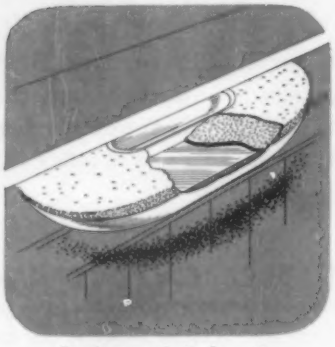
Casting compound for electrical applications



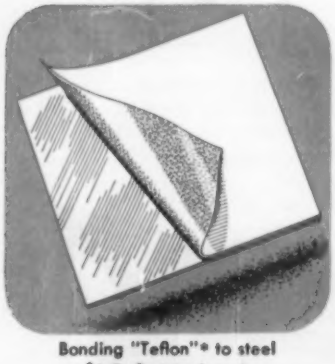
Bonding printed circuits



Bonding textile to textile



Bonding synthetic foam to metal in auto armrest



Bonding "Teflon"* to steel
*A Du Pont trademark

Sealer for automobile window channel

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The number of new places you can use adhesives today is growing faster than ever. With new bonding techniques, with modern Ray-BOND adhesives, you can cut fastening time and costs in a variety of applications never possible before.

R/M Ray-BOND adhesives are of two different types—thermosetting and thermoplastic. They are available in different degrees of viscosity—for either spraying or painting. They give top performance under the most severe operating conditions—withstand temperature extremes ranging from –80° to +700°F.

Whether or not you've yet considered bonding, laminating, sealing or coating in your own operations, talk to an R/M engineer now. From over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings, R/M has acquired a wealth of knowledge and experience that might help you find new ways to improve your product or cut costs. Write or call for complete information on new Ray-BOND adhesives now.

R/M Bulletin No. 700 contains engineering information you will want on Ray-BOND adhesives, protective coatings and sealers. Write for your free copy.

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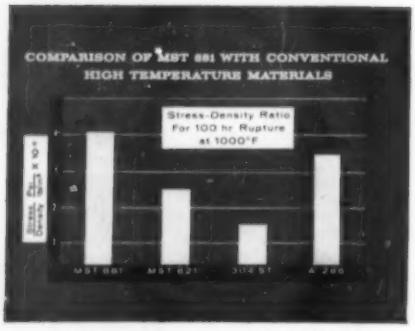
New Mallory-Sharon 1100° Titanium Alloy

MST 881

BREAKS THE HEAT BARRIER


COMPARISON OF MST 881 WITH CONVENTIONAL HIGH TEMPERATURE MATERIALS
Stress-Density Ratio For 100 hr Rupture at 1000°F
MST 881
MST 821
304 ST
A 286

Note high stress/density ratio of MST 881 at 1000° F., compared to MST 821 alloy, 304 and A 286 stainless steels.

Now, after 2½ years of intensive research, Mallory-Sharon has developed a new titanium alloy with elevated temperature properties far surpassing those of any existing titanium alloys.

At a temperature of 1000 degrees F., a level of increasing importance in the aircraft industry, MST 881 has *more than twice the creep strength* of any existing commercial titanium alloy. Even at 1100 degrees F., MST 881 will have only about 0.5% deformation at a stress of 25,000 psi.

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Cold Cabinet. Revco, Inc., 2 pp. Low temperature cabinet for industrial processes and research. 347

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PERFECT SURFACE . . . EXTREME HARDNESS . . . LOW COST

—all this and more, with LINDE Sapphire!

To assure dependability under the most severe conditions, tiny valve poppets and seats of pilot relief valves for space vehicle tanks built by Whittaker Controls are made from LINDE Sapphire. LINDE Sapphire was selected over other materials for this critical use because of its perfectly smooth surface, extreme hardness, and relatively low cost. Other advantages are resistance to corrosion and fast deliveries from LINDE.

Among other properties of LINDE Sapphire are zero porosity, great strength at elevated temperatures, and a high melting point of 2040° C. LINDE Sapphire is transparent, may be clear or red. It is easily sealed to metals or ceramics and has excellent IR transmission characteristics.

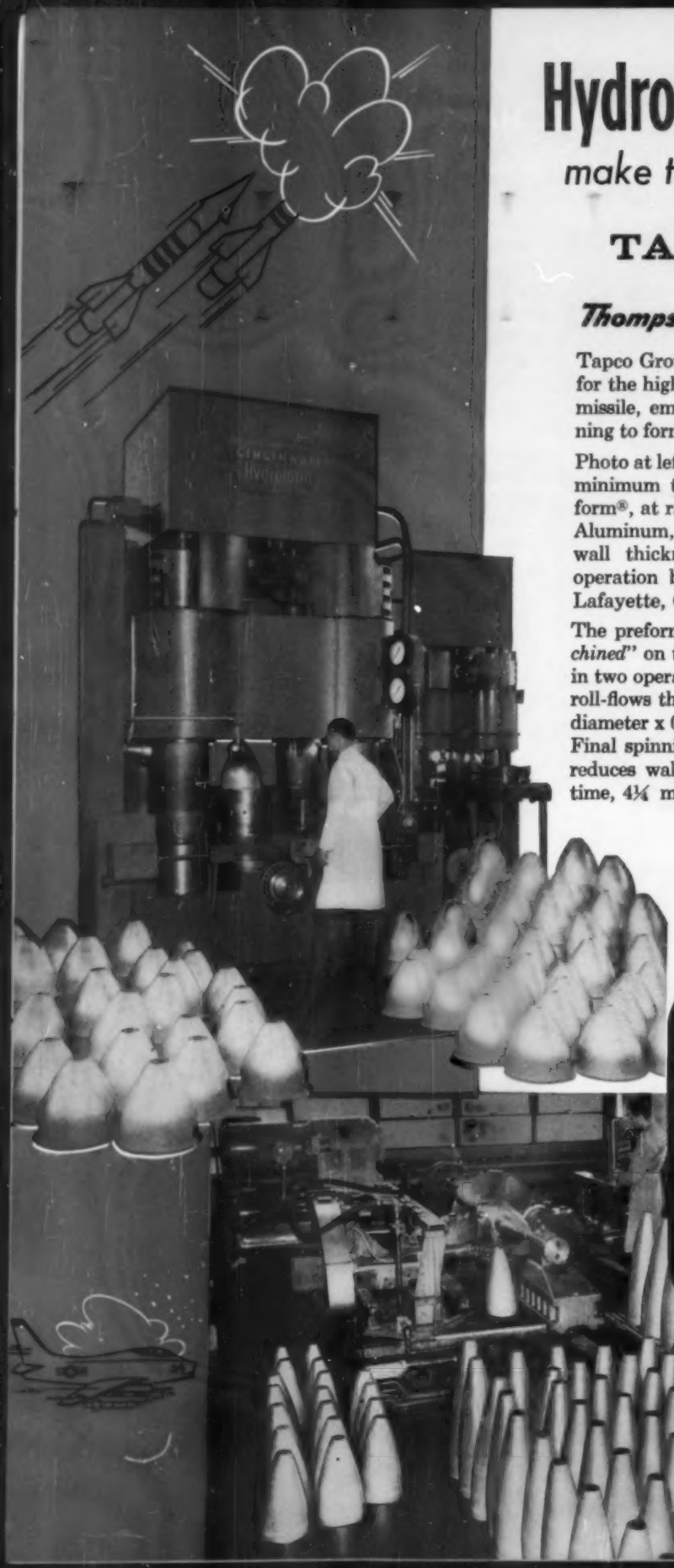
LINDE Sapphire is supplied in the form of balls, rods, tubes, domes, and special shapes to order. For more information, write Crystals Department, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Pilot section of this pressure relief valve has poppet ball (red) and seat of LINDE Sapphire. Valve was designed and manufactured by Whittaker Controls Division of Telecomputing Corporation.

Linde

UNION CARBIDE

Linde and Union Carbide are registered trade-marks of Union Carbide Corporation.



Cincinnati Hydroform · Hydrospin

make the nose sections flow for TAPCO GROUP of *Thompson Ramo Wooldridge Inc.*

Tapco Group, contractor to supply nose sections for the highly accurate, air-to-surface "Bullpup" missile, employs Hydroforming and Hydrospinning to form these parts at high production rates.

Photo at left shows preforms being produced with minimum thinout, on a Cincinnati 32″ Hydroform®, at rate of 90 per hour. Preform is of 6061 Aluminum, 14″ major diameter x 13″ deep x ⅛″ wall thickness. Preforming is a sub-contract operation by Jones Metal Products Co., West Lafayette, Ohio.

The preform is heat-treated, then "*chipless machined*" on the two-roller Cincinnati Hydrospin® in two operations (bottom photo). First spinning roll-flows the preform to 20″ length x 12″ major diameter x 0.080″ wall thickness, in 3½ minutes. Final spinning increases part length to 40″ and reduces wall thickness to 0.040″. Floor-to-floor time, 4¼ minutes.

For your missile metalworking, you'll save time and money by teaming-up with Cincinnati Hydroform and Hydrospin machines. Call in a Meta-Dynamics Division field engineer for detailed information.

Hydroform/Hydrospin

META-DYNAMICS DIVISION

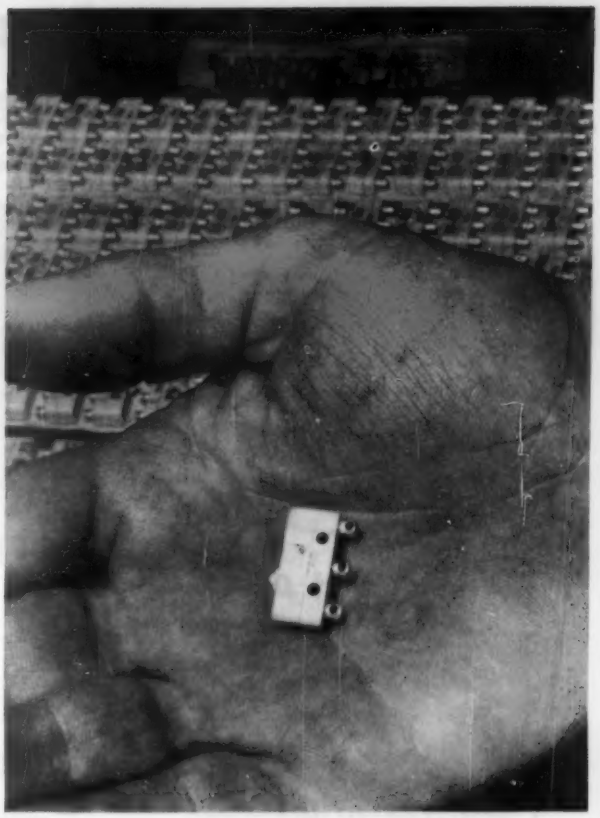
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

Sealed tight!

Yet inside contacts must be critically aligned and spaced

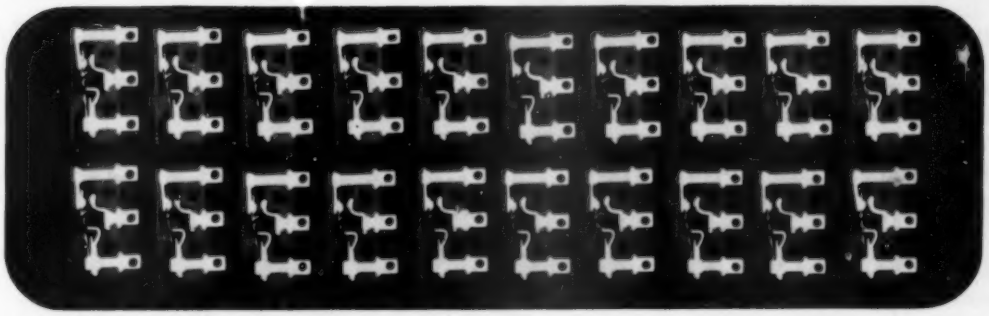


One of the miniature switches about to be radiographed at Burgoyne Testing Laboratories, Westbury, Long Island.

Specifications for these miniature switches are rigid. But one special military project (ballistic missiles) demands extra precision. Tolerances are reduced to a minimum.

What nondestructive test could be used to check the critical contact spacing and alignment? *The answer was radiography*—and the manufacturer assigned the inspection problem to the Burgoyne Testing Laboratory, Westbury, L.I. Radiographs of the switches—by lots—make it possible to select those that meet specifications.

In the quality control of cast or welded products and hidden assemblies, radiography plays an outstanding role. Perhaps it can help you to be sure that only acceptable items are delivered—a saving of time and money, and a great aid in building business. Why not call your x-ray dealer—or the Kodak technical representative—and talk it over.



Radiograph shows critical spacing of the switch contacts.

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- Speeds up radiographic examinations.
- Gives high subject contrast, increased detail and easy readability at all energy ranges.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

EASTMAN KODAK COMPANY, *X-ray Division*, Rochester 4, N. Y.

Kodak

◀ For more information, circle No. 473

For more information, turn to Reader Service card, circle No. 374

If your equipment is destined for exposure to chemical fumes, acid spillage, high humidity or other severe corrosion conditions, it's wise to safeguard your reputation — and your customer's investment — with Tygon Hot Spray vinyl coatings. Field tests have proved it: Tygon gives extra years of protection against most corrosive agents.

But that's just part of the story. Check these important *extra* benefits to you and your customers when Tygon is used.

✔ ***Faster, Easier Application.*** Tygon is easy to apply, dries to a dust-free finish in minutes, saves valuable time.

✔ ***Higher Build Per Coat.*** Because no thinners are needed, a thicker, denser film is deposited. Tygon provides a better finish, greater film thickness without sagging. Gives excellent build-up on sharp edges and other hard-to-protect spots such as rivets, bolt heads, threads, welds.

✔ ***Less Overspray.*** Means less masking, less material required, no paint fogging.

✔ ***Improves Product Saleability.*** In addition to its superior corrosion resistance, Tygon is noted for its non-toxicity, toughness, adhesion, resilience, flexibility and high resistance to mechanical damage. It is available in a variety of attractive, durable colors.

Tygon Coatings offer advantages over ordinary paint that customers really appreciate. Why not see for yourself what Tygon can do?

Tygon is a registered Trade Mark of The U. S. Stoneware Co.

Write for this TYGON DATA BOOK

Contains complete details on how and where to use Tygon Hot Spray, plus useful information on other Tygon Coatings.

187F-1

PLASTICS AND SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

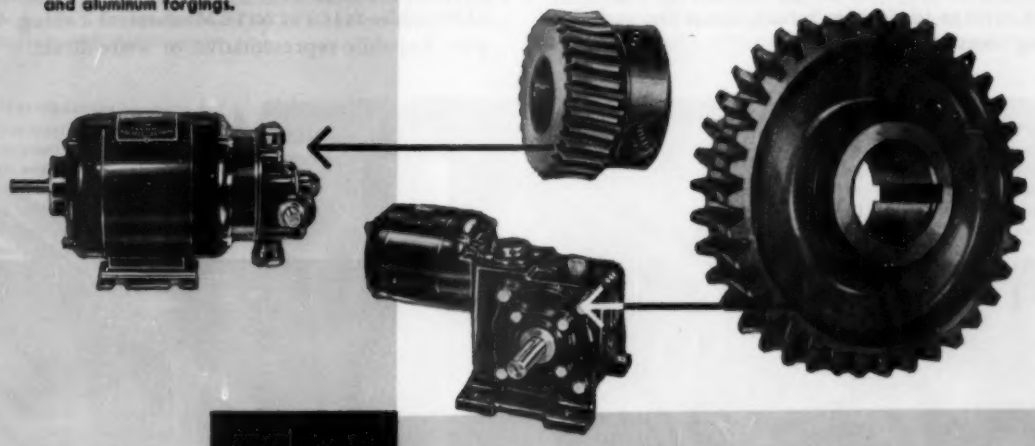
For more information, turn to Reader Service card, circle No. 445

MUELLER BRASS CO. forged gears improve dependability and performance of BODINE electric motors

For combined high shear strength and maximum wear life in their single and double reduction speed reducer motors, Bodine Electric Company of Chicago uses gears forged from Mueller Brass Co. 603 Alloy.

Bodine has specified Mueller Brass Co. forged gear blanks because of their consistently high quality . . . there is no porosity, foreign inclusions or defects typical of cast blanks. The hot working of the metal followed by heat treatment to the desired physical properties produces a refined grain structure to give uniform machining and wear in service. The forged blanks are consistent in size and held to close tolerances. Bodine has also found that the excellent machinability of the blanks in the hobbing operation increases overall hob life.

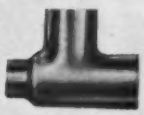
For forgings of high tensile strength, high density, minimum porosity, light weight, corrosion resistance, good machinability and low costs with little scrap loss, it pays to specify forgings from the Mueller Brass Co., the world's largest producer of brass, bronze and aluminum forgings.



only the man from Mueller Brass Co.

can offer unbiased advice on the "one best way" of producing your parts, because Mueller Brass Co. is the *only* fabricator in the country offering all these methods of production . . . assuring you the best product at the best price . . . made the one best way.

Write today for complete catalogs on any of these products.



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MUELLER BRASS CO. PORT HURON 21, MICHIGAN

262

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Republic ELECTRUNITE Mechanical Tubing

...facilities and abilities save production time, materials, costs!

This story is a typical example of how Republic's ELECTRUNITE® Mechanical Tubing—in rounds, squares, rectangles, can work for you.

Syncro Corporation, Oxford, Michigan, manufactures quality jig saws for home workshops. Previously, they used a casting for the blade-yoke which requires a severe bend. ELECTRUNITE Square Tubing was recommended for one model, rectangular tubing for the other.

Results: Reduction of weight of the blade-yoke and improvement in the appearance of the product, at a savings in time, materials, assembly, and shipping costs.

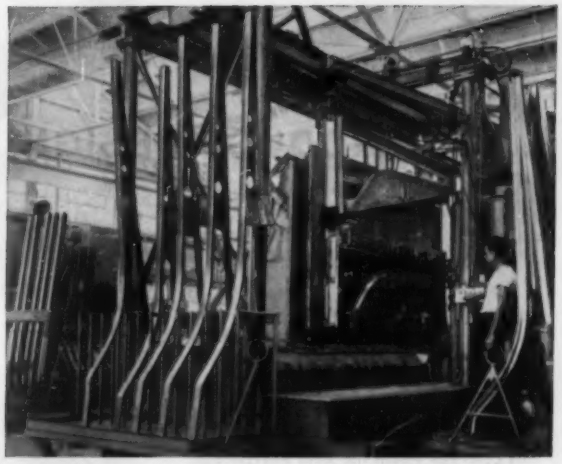
ELECTRUNITE solved this problem because Republic Mechanical Tubing is produced with the ability to withstand severe bending. In both models, ELECTRUNITE Mechanical Tubing is bent a full 180° without noticeable distortion or loss of strength.

Republic's Steel and Tubes Division has the facilities, equipment, and "know-how" to fabricate all grades and types of ELECTRUNITE carbon and stainless tubing into whatever shapes your product requires.

Learn more about the problem-solving advantages of Republic ELECTRUNITE Mechanical Tubing. Call your Republic representative, or write direct.

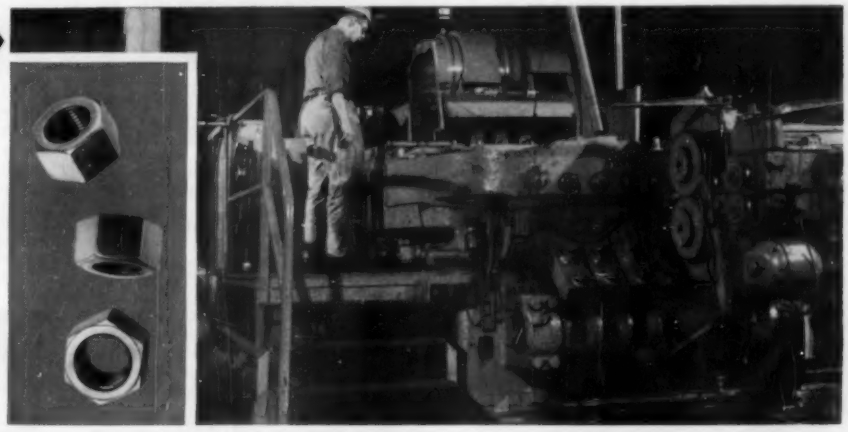
SYNCRO CORPORATION *manufactures quality jig saws for home workshops. Blade-yokes, made of Republic* ELECTRUNITE *Square and Rectangular Tubing bent a full 180°, are fabricated at Republic's Steel and Tubes Plant, Ferndale, Michigan.*

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE H.S. 6460, opens the way to new markets for new applications using sintering for highly stressed parts. Type H.S. 6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, 100,000 psi heat treated. Type H.S. 6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or in multiples thereof. Mail coupon for data.



REPUBLIC ALLOY STEEL SOLVES STRENGTH/WEIGHT PROBLEM. Rohr Aircraft Corporation, Chula Vista, California, is currently manufacturing flap tracks for an Air Force bomber fabricated from AMS 6428 Alloy Steel, with minimum tensile strength of 180,000 psi in the heat treated condition. Uniform response to heat treatment assures exceptionally deep hardening characteristics. Exceptionally high strength-to-weight ratio combined with highest strength values permits the design of thinner, lighter track sections. Save weight, hold down size without sacrifice of strength or safety. Send coupon for data.

THERE IS SATISFACTION in knowing that when you specify Republic Fasteners, you can count on consistent uniformity from one unit to the next, year in and year out. You get unswerving quality and dependability in each fastener, in any quantity. Skilled workmen, using modern production equipment like the nut former shown at right, maintain uniform quality in each type of fastener. Your Republic Bolt and Nut Division representative or distributor will be glad to work with you to make sure you get exactly the right fastener to suit your application. Send coupon for full information on types and sizes.



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- ☐ Republic ELECTRUNITE Mechanical Tubing
- ☐ Republic High Strength Powder, Type H.S. 6460
- ☐ Republic Alloy Steel
- ☐ Bolts and Nuts
- ☐ Have a metallurgist call

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For more information, turn to Reader Service Card, circle No. 444

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **A plastic for potentially hazardous locations**
- **Material for a non-warping switch**
- **More design freedom in metal castings**

Canopy retards fire

Good product ideas seem to work almost anywhere.

Take, for example, this plastic gas-station canopy. So far as we can tell, the idea of cool, light-diffusing canopies over the gas pumps started in the South, where it would seem to be a natural.

However, the canopy you see here is in Canada. It does most of its work in winter, when it may have to hold up the weight of five feet of snow and ice.

The marketing strategy is sound. A motorist doesn't mind so much getting out of his car in bad weather when he's protected overhead; and the attendant, too, is likelier to provide that extra bit of service.

There's something else that's different about this canopy. It doesn't support combustion, because it's made with Hetron® self-extinguishing polyester resin. A fire starting at a pump won't spread along the canopy to other pumps or to the station building.

If it weren't for self-snuffing Hetron, there'd be few places where a good idea like this could operate. Fire retardance is chemically locked into the resin, not added later at the expense of strength. The resulting combination of structural properties gives you something unique on which to base *your* new-product ideas.

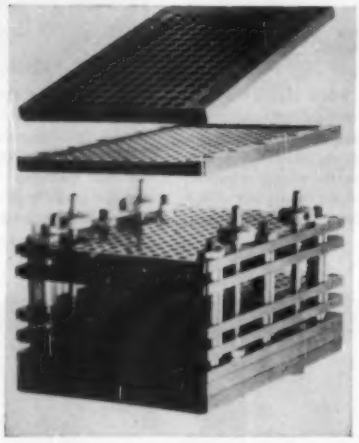
If you'd like to know more about Hetron resins, let us send you the complete technical data file, together with names of leading fabricators in this country and Canada who can make U/L-listed panels and custom-molded shapes for you.

Less dough for this "bread"

Needed: a dimensionally stable material for the "bread" in this sandwich-like multiple switch assembly (above right).

Why dimensionally stable? Because each of the seven "slices" in the sandwich has 187 holes that must line up with matching holes in the other plates.

What low-cost insulating material would hold alignment without risk of moisture absorption and warping? Could



holes be *molded*, rather than drilled, to the required accuracy? Would this save money?

The material recommended by the custom molder was a fast-curing Durez compound with good moldability and excellent dimensional stability. This material does everything the designers want it to do. Its exceptionally good mold release facilitates the low-cost molding of holes. In addition, numbers and letters which were formerly silk-screened on the plates are now molded-in for extra savings.

Result: a smooth-functioning, non-warping switch, produced with the utmost economy. It's just one more proof of the wide, wide spectrum of design requirements you can meet at low cost with Durez phenolics (and often *only* with phenolics). Want more information on these versatile molding compounds? Just check the coupon for a bulletin on Durez materials.

Castings – can do

Don't back off from a complex metal shape just because "it can't be done."

Instead, talk to your foundryman. He may have a surprise up his sleeve—*shell molding*. It saved the day for the aluminum-alloy gearbox cover, below.

Designers wanted as many heat-dissipating fins as possible; they compromised on 40. Even so, fins tore when the piece was poured in sand. Three men could produce only 20 good castings a day.

A switch to shell molding has made the casting economically feasible. Three men now turn out 70 per day. Dimensions are much more consistent from one casting to the next. As a bonus, engineers found they could squeeze two more fins into the design to get higher efficiency than they first believed possible.

What about cost? Shell-molded castings sometimes cost more *per pound* than regular castings. But they often save you far more than the difference—by reducing machining and finishing time and by speeding assembly.

Like to know how these better castings are made with the help of Durez foundry resins? We'll gladly send you the new 36-page "Durez Guide to Shell Molding" if you check the coupon below.

For more information on the Durez materials mentioned above, check here:

- ☐ Hetron fire-retardant polyester resins (50A)
- ☐ General bulletin on Durez materials (Bulletin 400)
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
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The new rugged, powerful Riley Pulverizer is an outstanding example of advanced functional design. A key to this Riley pioneering achievement is the use of tungsten carbide to increase the life and efficiency of pulverizer parts. Result . . . years of uninterrupted performance . . . minimized shut-down time . . . lowest operation costs.

Needless to say, pulverizers take tremendous punishment, but these are definitely built to "take it." *Riley specifications assure prolonged service.* The tungsten carbide facings are brazed to the pulverizer parts with Silvaloy—producing joints *as strong and dependable as the metals joined.*

* Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy Distributor for information or assistance.

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Riley pulverizers have been selected by many of the leading public utility and industrial companies for pulverizing coals of high grindability and abrasive high ash coals. The use of tungsten carbide as a facing for the pulverizing elements assures low maintenance, long continuous periods of operation, and sustained fineness with high availability.

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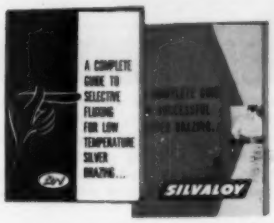


Two complete reference manuals for low-temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★ ★ ★ ★

For more information, turn to Reader Service card, circle No. 414

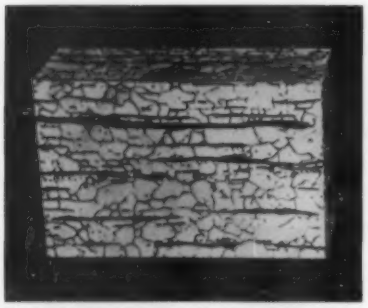
What every design engineer should know about

NEW 4-D WROUGHT IRON

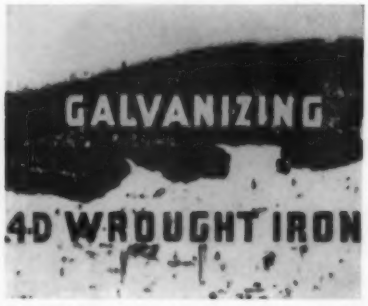
What 4-D is: Above all, it is a durable, corrosion-resistant material for equipment design and construction. 4-D Wrought Iron was achieved by substantially increasing the deoxidation of the base metal, slightly increasing its phosphorous content and using a more siliceous iron silicate.

Physical advantages: 4-D Wrought Iron is tough and resilient. Withstands repetitive vibration and shock. It is malleable, readily forged, cut, bent and threaded. Self-fluxing action produces sound, durable welds. Uniform structure contributes to smooth, sharp threads.

Where to use it: Any service or application requiring a tough, corrosion-resistant, easy-to-work metal in the form of pipe, plate, sheet, fittings, nipples, forged blooms, forgings, bars, rounds, squares, angles and other shapes. See us in Sweet's Product Design File: 1d/BY.



Photomicrograph shows why 4-D Wrought Iron resists corrosion: Iron silicate fibers entrained in high purity iron, 250,000 per cross sectional square inch. Non-rusting glasslike fibers detour corrosion, forcing it to spread in a dense protective coating over the entire surface of metal.



Entrained iron silicate imparts a microscopically rougher surface to 4-D Wrought Iron which is accentuated by pickling. This provides good "teeth" or anchorage for paints and galvanizing. 4-D Wrought Iron takes up to a 50% tighter, heavier coating than other ferrous materials.

The silicate fibers threaded through 4-D Wrought Iron distribute and divert stress concentrations and reduce possibility of fatigue failure. Bar fracture shows hickory-like toughness. This accounts fc 4-D's effectiveness in services where shock and vibration discourage use of other metals.

Write for literature and specific information on properties and design capabilities.

BYERS 4-D WROUGHT IRON

TUBULAR AND FLAT ROLLED PRODUCTS

A. M. BYERS CO., CLARK BLDG., PITTSBURGH 22, PA.

4-D Wrought Iron makes corrosion work for you

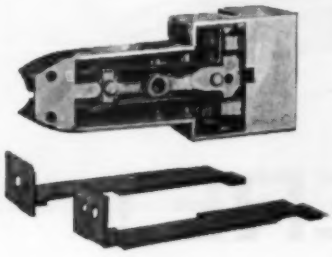
For more information, turn to Reader Service Card, circle No. 482

CONTACT!

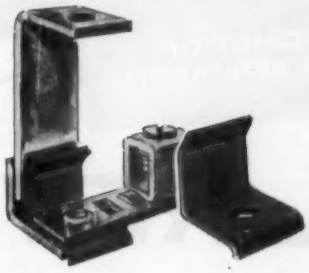
NEW "CONTACT BRONZE" STRIP KEEPS THE SPRING IN FORMED CONTACT PARTS, YET COSTS UP TO 25% LESS!

Manufacturers can now form intricate contact parts that cost less from Bridgeport's new "Contact Bronze" strip. High quality is maintained in this new, red color alloy strip by the addition of a minute quantity of phosphorus, which provides superior spring properties, even in hard-to-form parts.

Specially engineered for the electronics industry, Bridgeport "Contact Bronze" Alloy 92 costs up to 25% *less* than metals previously used for this application. If you form or stamp shaped contact parts, learn how "Contact Bronze" can maintain quality at lower cost. Samples and a copy of the "Contact Bronze" data sheet are available from your nearest Bridgeport Sales Office. Call or write today!



These electrical terminals were originally made of phosphor bronze. Parts now are produced from Bridgeport "Contact Bronze" 92—at appreciable savings.



American Electric Switch Division, Clark Controller Co., Cleveland, Ohio, wanted a lower-cost material for pressure clips. Bridgeport "Contact Bronze" 92 met all specifications . . . good electrical conductivity to reduce heating, superior spring and mechanical properties—and all at lower cost.

A leading manufacturer of control switches needed these fuse clips with special mechanical and electrical properties. Bridgeport "Contact Bronze" 92 met the specifications—at lower cost.

matched Bridgeport Metals *to your job*

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Bridgeport Brass Company, Bridgeport 2, Conn. • Sales Offices in Principal Cities. (Dept. 3501)

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When you want ALUMINUM SHEET...

CALL REVERE!

You can be sure, when you specify or order from Revere, that you will get not only fine metal but fine service, including Revere's cost-saving Technical Advisory Service if desired. Revere—now an integrated producer of aluminum—can supply you from large modern sheet mills in Baltimore, Md., and Chicago, Ill.

In addition to aluminum coiled and flat sheet, circles and blanks, both plain and embossed, Revere can furnish aluminum seamless drawn, welded and extruded tube; extruded shapes; forgings; foil; and primary aluminum pig and ingot.

It pays to do business with the most dependable sources of supply—such as Revere, which has been fabricating fine non-ferrous metals for more than 150 years.

Revere Aluminum Coiled and Flat Sheet
up to 48" wide and up to .125" thick

Alloys			
1100	3003	5005	5052
1145	3004	5050	5357

COPPER • BRASS IS OUR REVERE ALUMINUM

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

For more information, turn to Reader Service card, circle No. 419

Tool Steel Topics

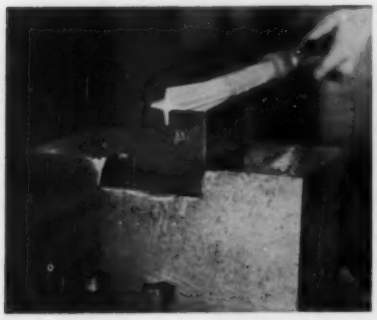
BETHLEHEM STEEL

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributors: Bethlehem Steel Export Corporation

57 HW tool steel forges star drills while they're red hot



In the Hampstead, Md., plant of Black & Decker Manufacturing Co., they needed a hot-work tool steel for use in the hot forging of star drills. The drills were to be made from 7/8-in. carbon steel. The tool steel for the forging dies had to be easy to machine, have good resistance to wash, and stay on the job for long periods.

Several competitive tool steels were tried, but their major shortcoming was insufficient resistance to wash in critical areas of the die. Then Bethlehem 57 HW was used because of its high tungsten content, which leads to excellent resistance to wash and wear.

After the 57 HW die had been in service for some time, we learned that it had given a good account of itself in this application. The die had been hardened to approximately Rockwell C46. It was extremely economical because of the way it stayed on the job.

Once again a Bethlehem tool steel had provided outstanding service in the field.

57 HW (AISI H-21) is our 9 pct tungsten type of hot-work tool steel. Air-hardened, it has high red-hardness and high abrasion-resistance. It also has good resistance to heat-checking, and can take plenty of shock.

Typical Analysis

Carbon	0.35	Tungsten	9.35
Chromium	3.25	Vanadium	0.50

57 HW has been proved in many hot-work applications. But don't take our word for it. Give it a trial in your shop. You'll find your Bethlehem tool steel distributor at your service.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Brake Die Steel Can Be Flame Hardened

Brake Die tool steel bars are furnished in the heat-treated condition (squares and flats Brinell 248/293, and rounds 302/352) so that the customer merely has to machine the tool to the dimensions desired. For many types of metal forming operations, Brake Die steel does an excellent job. On some operations, however, certain areas of the dies may wear away faster than others. A common cure for this trouble is to use small inserts of BTR, our standard manganese oil-hardening tool steel, hardened to Rockwell C58-60 at the wear points.

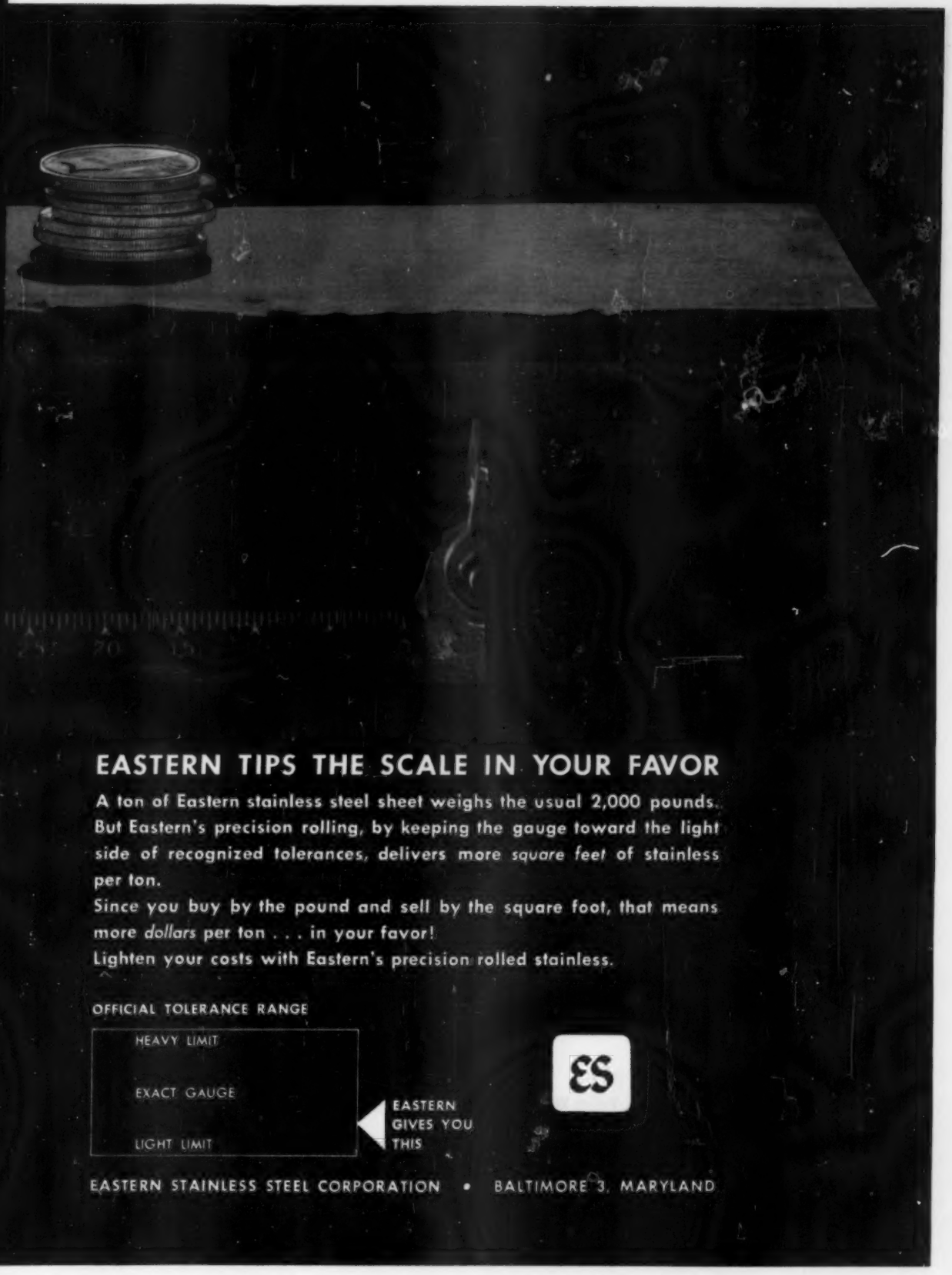
A more economical way to solve this problem is to locally flame-harden the Brake Die steel at the wear points. Small surface areas on tools made of Brake Die steel can be hardened by merely heating with an oxy-acetylene torch for a few seconds (long enough to heat the surface to a definite red color, approximately 1500F). No quenching is required. The portion of the steel which is heated will harden to Rockwell C55-60 because of the rapid cooling produced by the conduction of heat from the small heated spot into the larger adjacent areas which have not been heated.

Flame hardening is not ordinarily considered for hardening tools, but here is the exception which proves the rule.

Why They Go for A-H5

In this shop, they wanted to combine long wear and minimum distortion on various types of trimming and blanking dies. They chose A-H5 (SAE A-2), and it did everything expected of it, and then some. A-H5 is our medium alloy air-hardening grade, with 5 pct chromium. It holds a keen cutting edge, has good resistance to abrasion and wear, and good deep-hardening properties. It's also easy to machine, as indicated above.

For more information, turn to Reader Service Card, circle No. 393


EASTERN TIPS THE SCALE IN YOUR FAVOR
A ton of Eastern stainless steel sheet weighs the usual 2,000 pounds. But Eastern's precision rolling, by keeping the gauge toward the light side of recognized tolerances, delivers more square feet of stainless per ton.
Since you buy by the pound and sell by the square foot, that means more dollars per ton . . . in your favor!
Lighten your costs with Eastern's precision rolled stainless.
OFFICIAL TOLERANCE RANGE
HEAVY LIMIT
EXACT GAUGE
LIGHT LIMIT
EASTERN GIVES YOU THIS
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EASTERN STAINLESS STEEL CORPORATION • BALTIMORE 3, MARYLAND

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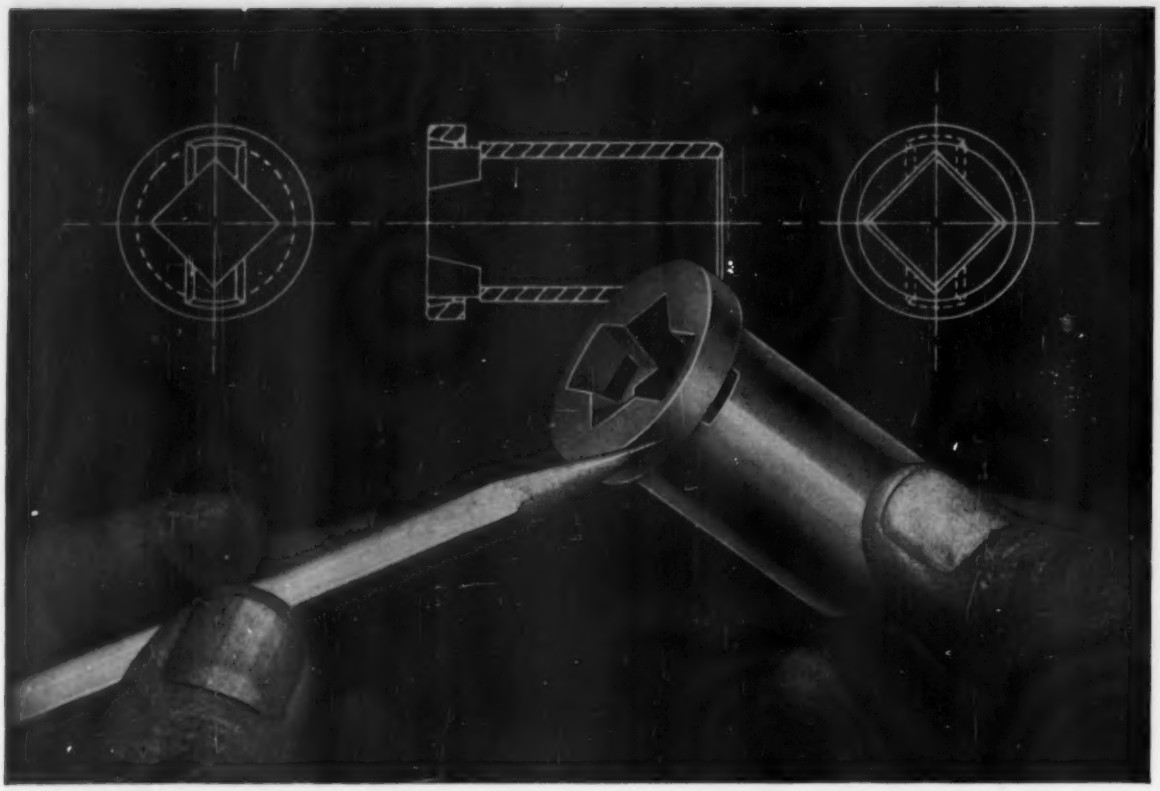

How Would YOU Produce This Part With No Machining . . . No Scrap Metal?

PARKER SALES ENGINEERS

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Warren G. Olson • 420 East Linn Street

CHICAGO 49, Ill.
Clyde J. Berger Company • 2059 East 72 Street

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DETROIT 35, Mich.
Hodgson-Geisler Co. • 10917 James Couzens

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Box 26

Can't be done? Parker did it . . . sharp internal corners, lateral holes, chamfers, flanged end and all . . . by fast, low-cost powdered metal pressing and sintering. No subsequent machining . . . no scrap-metal loss. Just think of the savings compared with conventional machining methods.

In addition to these inherent cost savings, Parker-engineered Powdered Metal Parts offer a wide choice of tensiles, ductility, density, impact resistance and other physicals. Tooling-up is done quickly and at relatively low cost.

It will pay you to check on the economies and design possibilities of Parker-engineered Powdered Metal Parts. Just call the nearest sales engineer listed here or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

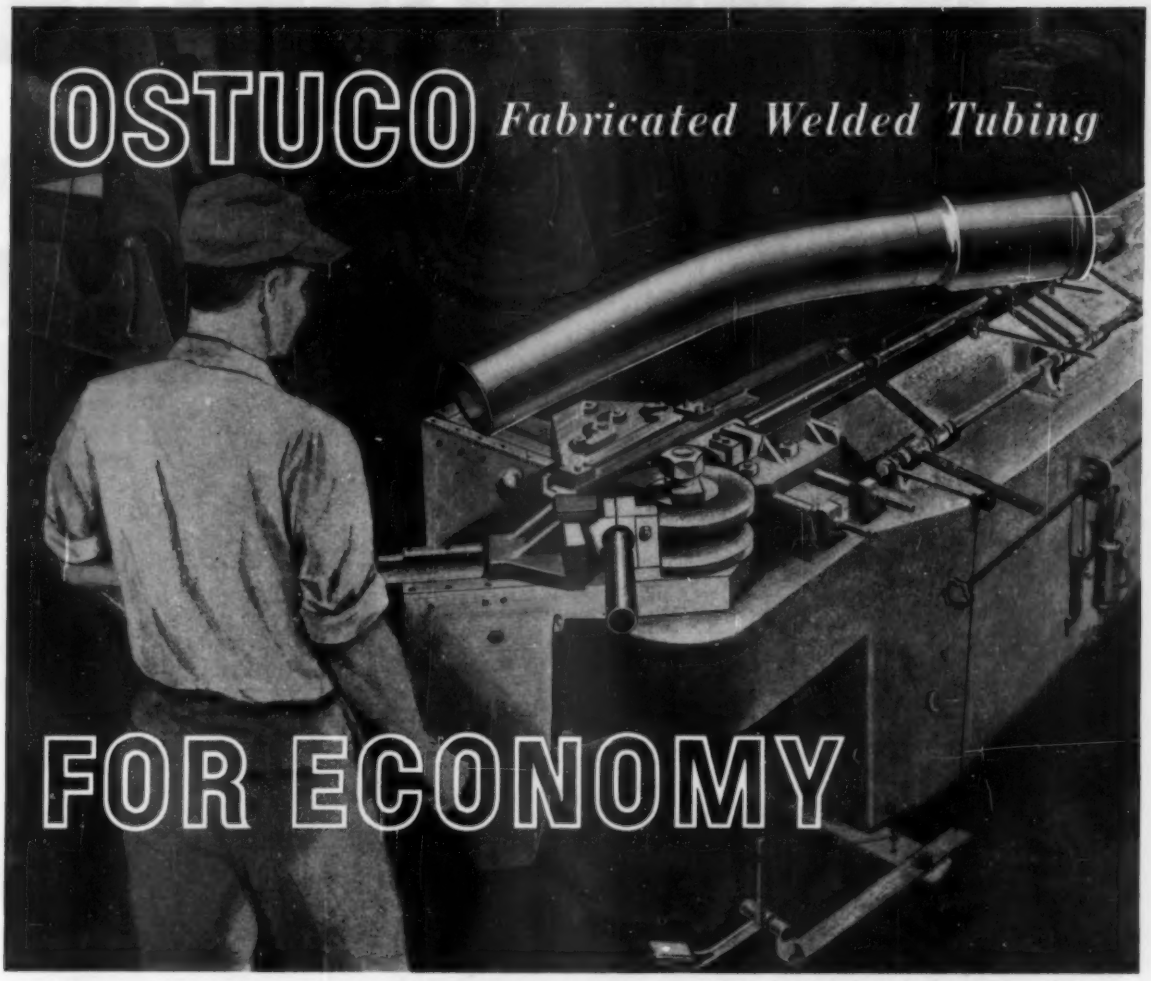
PARKER

high pressure ALUMINUM and ZINC die castings
POWDERED METAL PARTS

For more information, turn to Reader Service Card, circle No. 390

Vacuum Cleaner Manufacturer Specifies

OSTUCO *Fabricated Welded Tubing*



Bending vacuum cleaner wand. A variety of fabricating operations also is performed on Ohio Special Quality Seamless Tubing.

"Value analysis showed it would be more economical to buy than produce fabricated welded tubing parts for our new cleaner. What's more, we could avoid additional capital investment in equipment.

"So we added Ohio Seamless to our production line. They have the equipment and facilities to meet our design requirements and to hold to our stepped-up schedules. And we don't pay shipping costs on scrap — just on finished parts . . . "

Let Ohio Seamless translate your designs into finished parts . . . conserve your capital . . . cut your production and shipping costs. Contact your Ohio Seamless representative, listed in the Yellow Pages, or the mill at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-6947

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Sales offices: Cunningham Building, Cleveland, Ohio; Commercial Trust Building, Philadelphia (Bryn Mawr), Pennsylvania; Rockefeller Building, Pittsburgh, Pennsylvania; Rockefeller Building, Cleveland, Ohio; Syndicate Trust Building, St. Louis, Missouri; Hurt Building, Atlanta, Georgia; Hotel Jung Building, New Orleans (Chalmette), Louisiana; New York, North Kansas City, Philadelphia (Wyncote), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburg, Salt Lake City, Seattle, Tulsa, Wichita. CANADA: Page-Hersey Tubes Ltd., Toronto. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York.

For more information, turn to Reader Service card, circle No. 455

BONDERITE

ALUMINUM SIDING TEST

Regular 1-coat paint finish over section of Bonderite treated aluminum siding. Formed after painting. Tested in salt spray 1500 hours.

Aluminum siding made by Hastings Aluminum Products, Inc. Hastings, Michigan

for ALUMINUM

Better paint adhesion...better corrosion control

In two hundred plants—many of them the leaders in their particular fields of aluminum fabrication—Bonderite for aluminum is being used today!

Bonderite makes it possible to take aluminum in the coil, run it through a continuous line in which the strip is cleaned, Bonderized, roll-coat painted, dried—and then recoiled.

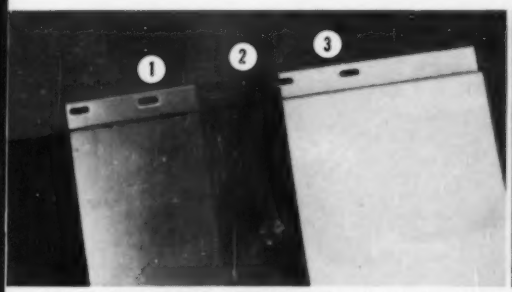
Because Bonderite gives paint such a secure foothold, it will stand severe forming operations (see photo below). With the Bonderite corrosion barrier at work, durability of the paint finish is almost indefinitely prolonged.

Bonderite meets and exceeds the requirements of Government Specification MIL-C-5541. Bare corrosion resistance is outstanding.

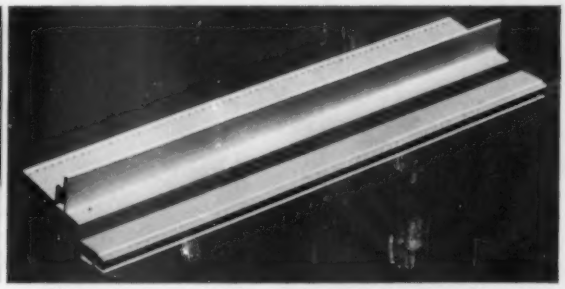
There's more than one type of Bonderite for aluminum. Besides the paint base, there's a Bonderite that creates a pleasant green coating, for use on architectural products. There's a Bonderite which protects without changing the characteristic color of the aluminum. Another Bonderite coats aluminum, steel and zinc—just the thing for mixed production.

There is a Bonderite, in fact, for every form of aluminum production, and for practically every alloy.

The big news in surface treatment for aluminum today is Bonderite! Let a Parker man tell you all about it!



Here's the 1-2-3 for durability of painted aluminum. Section of siding shows bare aluminum, (1); Bonderite treated, (2); and roll-coated paint, (3).



These aluminum window and screen frame sections were Bonderized and painted in the strip and formed after painting. There isn't a break in the finish anywhere!

Since 1914—leader in the field

PARKER RUST PROOF COMPANY

2173 E. Milwaukee, Detroit 11, Michigan
Tel: TRinity 5-3377

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite– Reg. U.S. Pat. Off.*

For more information, turn to Reader Service Card, circle No. 381

KIEKHAEFER MERCURY

Combines GOOD DESIGN and RIGID-tex® METAL

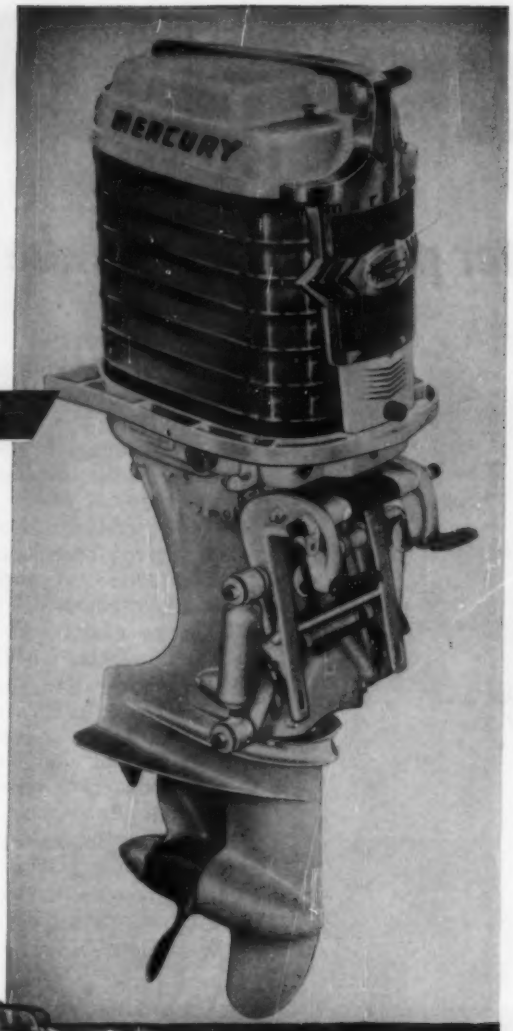
Result:

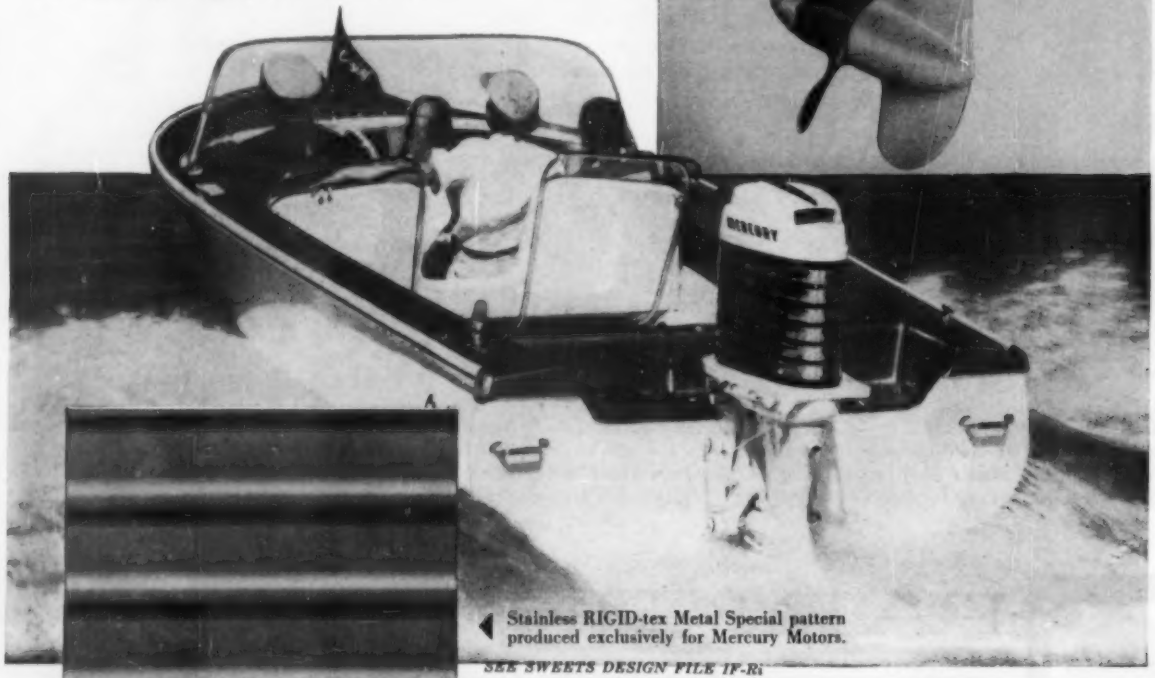
BEAUTILITY®

Mercury is the leading independent name in Outboard Motors. It is modern in engineering . . . design . . . appearance. Only Mercury offers 4- and 6-in-line power all the way up to 70 hp! Only Mercury has 10 years of high horsepower experience.

You can always spot a Mercury motor by its gleaming, stainless steel RIGID-tex Metal cowling. A sound absorbing blanket inside the cowling reduces powerhead noises. The special pattern which is the engine manufacturer's own design is produced for them *exclusively*. It adds rigidity without adding weight. It withstands ordinary knocks and abuse without denting and its bright surface will always remain beautiful.

RIGID-tex Metal is available in all metals . . . all colors. There are more than 45 standard patterns from which to choose. Phone or write for complete information.





Stainless RIGID-tex Metal Special pattern produced exclusively for Mercury Motors.

SEE SWEETS DESIGN FILE IF-Ri

RIGIDIZED METALS CORPORATION

6601 OHIO STREET • BUFFALO, N. Y.

World-Wide Distribution

For more information, turn to Reader Service card, circle No. 471

"WEIRKOTE'S" SOMETHING SPECIAL! IT CAN END THE NEED FOR ANY FURTHER CORROSION PROTECTION AFTER FABRICATION."

Q. You mean it? Weirkote can save you the cost of any further processing for corrosion protection after fabrication?

A. Absolutely. It's the continuous process that does it. Integrates the zinc to the steel so tightly there's never any peeling or flaking. No matter how severe the fabrication—any torture test you put it through—that bond stays put!

Q. Hmmm. Weirkote sounds great. One thing—is its zinc coating uniform throughout?

A. To the nth degree! Even the hardest-to-reach areas on the most complicated fabrications are completely protected.

Q. Corrosion-protected, you mean?

A. Corrosion-protected all over! So much so that you can work Weirkote to the very limits of the steel itself. So there you have it: stepped-up manufacturing efficiency, sharply curtailed manufacturing costs. All from Weirkote!

Send for free booklet that details the time-and-cost-saving advantages of skin-tight zinc-coated Weirkote. Just write Weirton Steel Company, Dept. E-1, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 430

New 1959 Toro mowers use .

1

MARLEX Engine Canopy

- **Does not conduct heat**—prevents burns.
- **Will not discolor** from gas, oil or heat.
- **Resists shock**—protects engine from damage.
- **Rigid**—keeps out branches when trimming, leaves cooling system open.

2

MARLEX Discharge Deflector

- **No sharp edges** to cut or scrape operator.
- **Lightweight**—machine is balanced for easy handling.
- **Takes a punch!** MARLEX deflector helps aim discharged material safely down away from operator.

3

MARLEX Discharge chute for bagging attachment

- **Absorbs shock** of vacuumed-up material being blown out of machine.
- **Unbreakable**—MARLEX can take all sorts of punishment. Won't crack, rust or corrode.
- **Wears and wears**—resists abrasion from discharged material.

MARLEX COMPONENTS MOLDED BY FLAMBEAU PLASTICS CORP., BARABOO, WISCONSIN

. . . MARLEX*

. . . for lightweight, durable, abrasion-resistant parts

These new Toro rotary mowers incorporate three MARLEX linear polyethylene components in their ultra-modern design . . . the engine canopy, discharge deflector and discharge chute.

During the selection of a material for these parts, many plastics were tried, but MARLEX was the only resin that successfully withstood the severe shock-loading and abrasion tests!

Toro truly set the pace in 1959 power mower design when they chose MARLEX, the versatile new heavy-duty rigid polyethylene.

No other material serves so well and so economically in so many different applications.

How can MARLEX serve you?

* MARLEX is a trademark for Phillips family of olefin polymers.

* * * *

The new Toro Whirlwind Mower's styling was directed by Charles Butler, president of Charles Butler Associates, New York. This design firm also has a designer working full time with engineers at the Toro Research & Development Center in Minneapolis. Three years of research and experimentation went into the engineering of the housing alone!

When the designs of the MARLEX components were approved, Toro called in Flambeau Plastics Corp., of Baraboo, Wisconsin to engineer the mold design and mold the parts. Flambeau, working with Phillips Sales Service Laboratory engineers, designed special multiple-gated hot-runner molds to handle the injection molding of these unusually complex pieces.

PHILLIPS CHEMICAL COMPANY, Bartlesville, Okla.

A subsidiary of Phillips Petroleum Company

PLASTICS SALES OFFICES

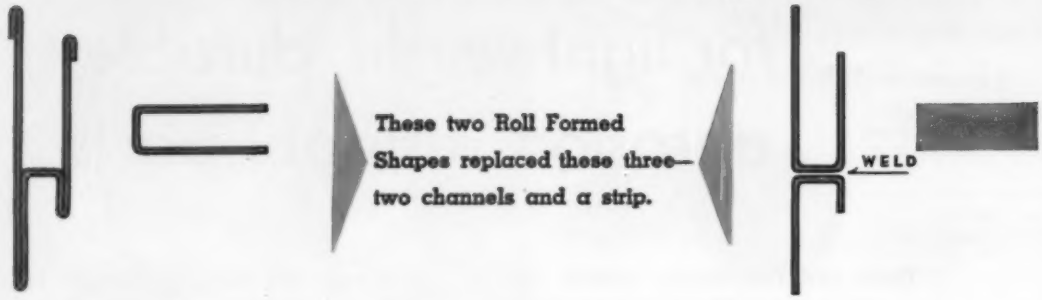
NEW ENGLAND	NEW YORK	AKRON	CHICAGO	WESTERN	SOUTHERN
322 Waterman Avenue	80 Broadway, Suite 4300	318 Water Street	111 S. York Street	317 N. Lake Ave.	6010 Sherry Lane
East Providence 14, R.I.	New York 5, N. Y.	Akron 8, Ohio	Elmhurst, Ill.	Pasadena, Calif.	Dallas, Texas
GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	RYan 1-6997	EMerson 8-1258

EXPORT: 80 Broadway, Suite 4300, New York 5, N.Y.

MARLEX Phillips 66

For more information, turn to Reader Service card, circle No. 457

2 parts replace 3 and reduce assembly costs



IN DESIGN

Product design created production problems. Solid strip was difficult to obtain. It was replaced by a Roll Formed U channel which weighs 55 % less. Many cut hands resulted from old channels. Hemmed edges on special Roll Formed shape eliminated this hazard. Dimensions are identical and structural strength is improved. Over-all appearance is decidedly improved.

IN PRODUCTION

Old assembly required 10 welds — 6 on channels and 4 in assembly. Roll Formed shape requires just 4 tack welds in assembly. One supplier and just two components permit deliveries keyed to production needs. Hemmed edges on H shapes eliminated cut hands on assembly line.

IN PURCHASING

Bookkeeping reduced by elimination of one item. Deliveries on time and keyed to production needs. Total costs on purchased items and assembly time were drastically reduced. Shipping weight reduced and net profit on the completed item was increased.

METALS AND TECHNIQUES

Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered burr-free to match your production schedule.

CAN ROLL FORMED HELP YOU?

Probably yes. The Roll Formed man can tell you. He'll go over your prints . . . work out an applicable section . . . plan deliveries with you. Meanwhile, you'll want Roll Formed Bulletin 1017. It shows how Roll Formed techniques give greater design freedom, increase production and help eliminate purchasing headaches. Get Bulletin 1017 today.

ROLL FORMED PRODUCTS
COMPANY

MAIN OFFICE AND PLANT • 3752 OAKWOOD AVE. • YOUNGSTOWN, OHIO

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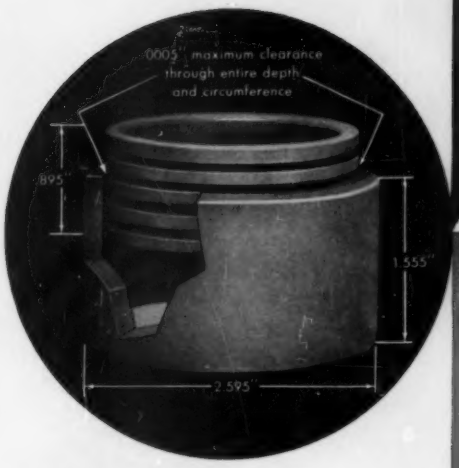

Superior Electromechanical Design Your job . . . and Centralab's

Difficult shapes to exacting specifications in Centralab 85%, 95%, 99% HIGH ALUMINA CERAMICS

Perfect concentricity must be maintained in the manufacture of this sleeve and piston assembly used in jet aircraft. Here it has been achieved in a 2.225" diameter, .895" thick sleeve with a .0005" maximum clearance between sleeve and piston. This is typical of Centralab's ability to control the manufacturing of ceramic parts to extremely close tolerances, no matter how complex the shape, how intricate the machining.

Centralab High Alumina will meet your most exacting specifications when you require a material with any combination of these properties:

- Tolerances to ± .00025
- Compressive strength to 300,000 lb./sq. in.
- Flexural strength to 54,000 lb./sq. in.
- Stability to 1485° C
- Inert to oils, acids, alkalis
- Unaffected by radiation, oxidation, or corrosion
- Dielectric constant 8.7-9.3 at 1 Mc
- Power factor .0002 at 1 Mc
- Loss factor .002 at 1 Mc

High Aluminas are stronger than steatite, and in many applications are more effective than metal. All Centralab High Aluminas conform to JAN 1-10-L6A specifications.

Centralab's modern facilities, including a kiln especially designed for High Alumina production (the only one of its kind in the United States) and Centralab's experience—over 30 years in engineered ceramics—are your assurance of reliability, quality and versatility.

A New Design Handbook containing detailed engineering data on the use of Centralab High Alumina and Steatite engineered ceramics is available free. Write for Bulletin 42-554.

Centralab X-5903

A DIVISION OF GLOBE-UNION INC.
946A EAST KEEFE AVE. • MILWAUKEE 1, WIS.
In Canada: 804 Mt. Pleasant Rd., Toronto 12, Ont.

VARIABLE RESISTORS • ELECTRONIC SWITCHES • CERAMIC CAPACITORS • PACKAGED ELECTRONIC CIRCUITS • ENGINEERED CERAMICS

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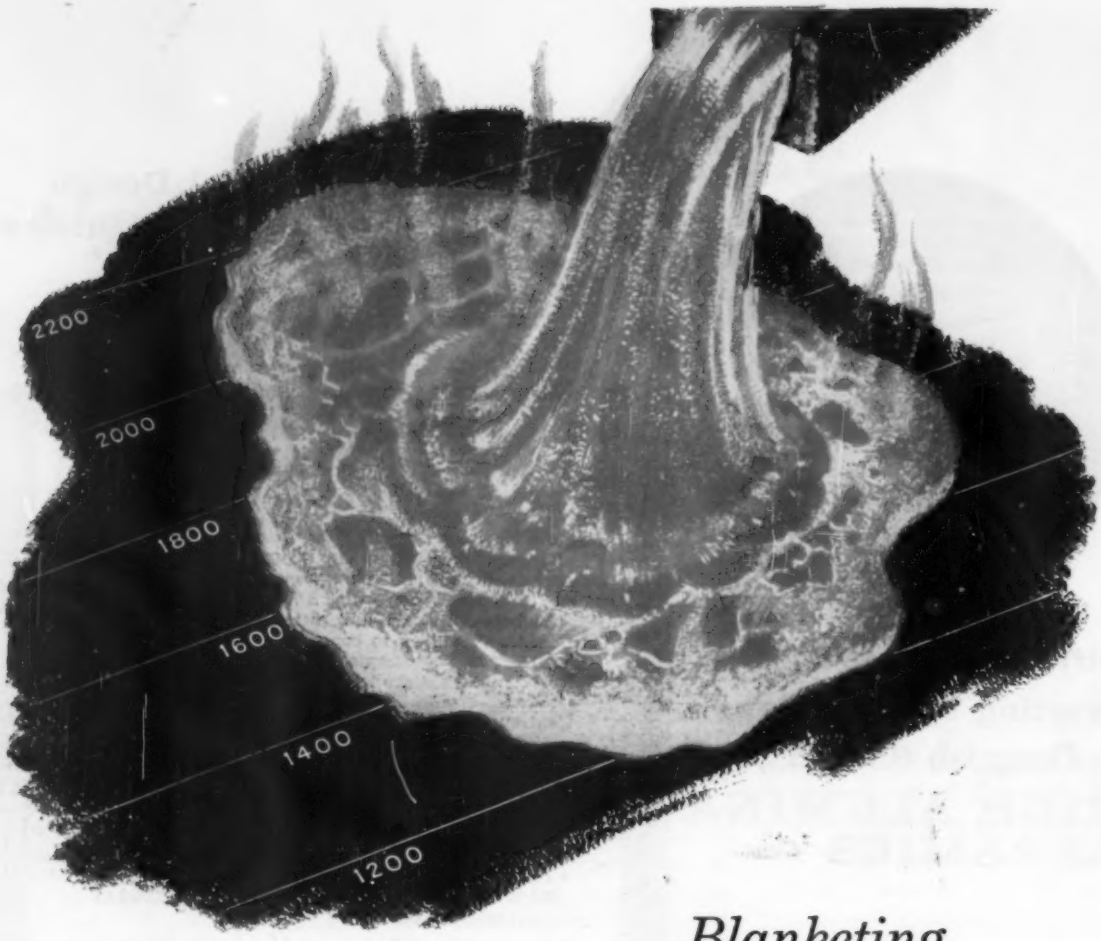


Blanketing the high temperature field

Close control is exercised over every step in the production of HAYNES alloys. This electric arc furnace is part of the modern mill set-up maintained at HAYNES STELLITE.

A fairly ambitious claim! Yet we can prove that HAYNES alloys do exactly that . . . all the way up to 2000+ deg. F. Here's why. There are 12 HAYNES high-temperature alloys. Among them you will find the right combination of properties to handle any heat condition. For example, HASTELLOY alloy X has remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 is strong and resists stresses, oxidation, and carburization up to 2000 deg. F. HASTELLOY alloy R-235 is outstanding in the 1500 to 1750 deg. F. range. And this is only part of the story. All 12 HAYNES alloys are *production* alloys and are readily available. Some of them are vacuum melted; some air melted. Some are cast, some wrought, and some are produced in both forms. For the full story, write for literature.

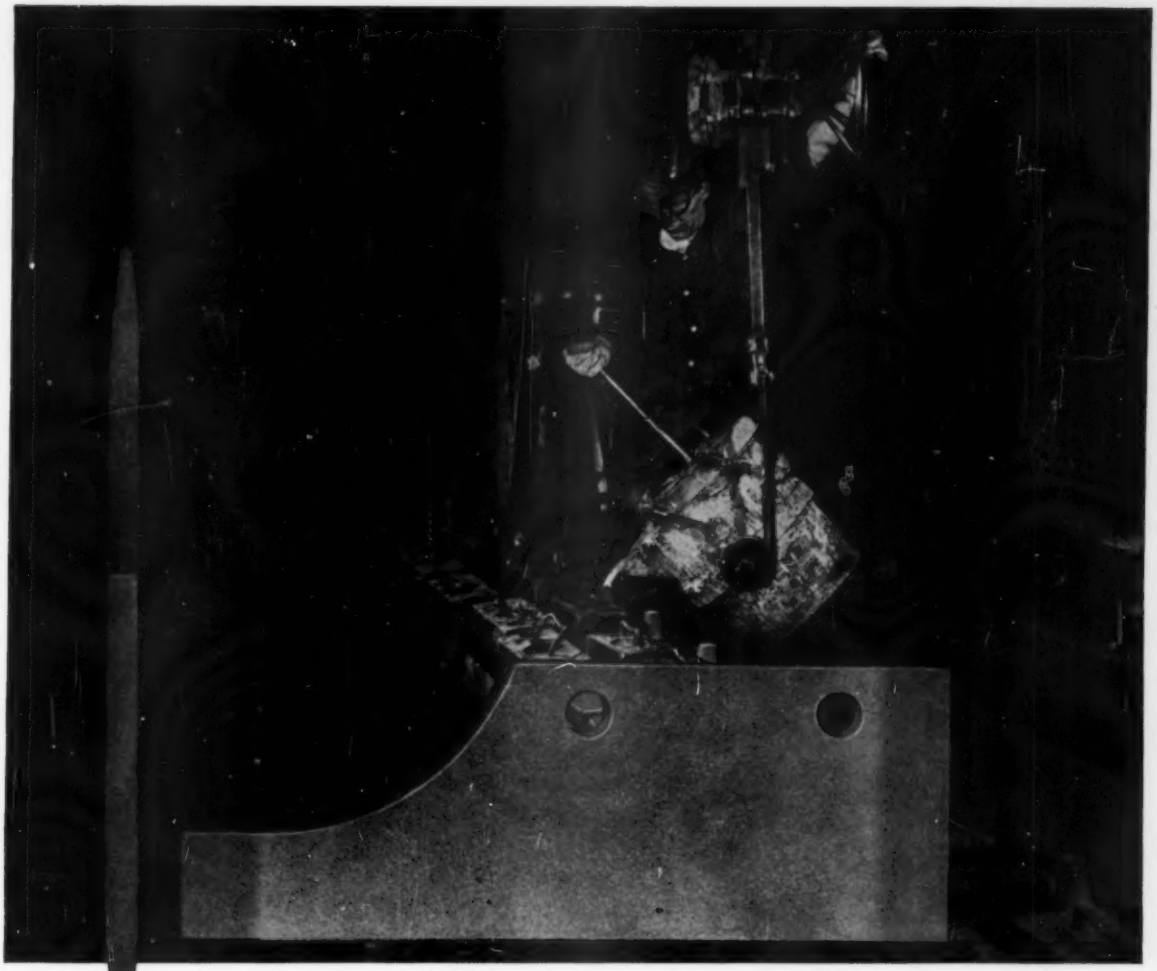
HAYNES ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 428



This customer SAVED TWICE with Ampco Shell Moldings

Gear blank shell-cast in Ampcoloy nickel bronze. Surface finish was held to ± .015. Only finishing required was to hob teeth and broach key-way. Savings were considerable.

In the wear strip above, shell-cast of Ampco Metal, all dimensions including end-bevels and hole locations were held to ±.015. The smooth surface finish required no machining. Substantial savings of time and money were realized.

With Ampco Shell Moldings, castings can be held to extremely favorable tolerances. Finishing operations are often eliminated; less metal is wasted. More of the tough outer cast shell is retained, providing longer service life.

Casting detail is excellent — oil grooves, deep pockets, and recesses can be cast in, and coring is close and precise, for complex designs impractical by other methods. High production rates reduce molding costs.

Ampco Shell Moldings are available in an extremely wide range of copper-base alloys. Ask an Ampco field engineer to tell you more about this money-saving production process. And write for Bulletin G36-957. *Ampco Metal, Inc., Dept. MD-10A, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, Calif.—Southwest: Garland [Dallas County], Texas)*

G-16

AMPCO

ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

For more information, turn to Reader Service card, circle No. 409

Color micrograph of heat tinted section of ferritic Malleable iron showing random dispersion of temper carbon nodules in ferrite. 625X magnification.

Usability is Malleable

In the growing world of metals, certain requirements remain basic: strength . . . versatility . . . economy. Malleable iron castings uniquely answer all three. Malleable castings provide more strength per dollar than any other metal . . . are the most machinable of all ferrous metals of similar hardness.

From the great range of Malleable irons now produced in modern Malleable foundries, you can select exactly the right metal to fill your most demanding needs for endurance, resistance to impact and wear, ductility and constant uniformity. No other metal offers you so much at so low a cost.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

(*Advertisement*)

These companies are members of the

MALLEABLE CASTINGS COUNCIL

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Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Select the Best Metal to Perform a Given Set of Functions

Any equipment part can be described, at least approximately, in terms of the functions it must perform. That is, it must provide a certain strength plus resistance to wear, fatigue, impact or corrosion. The finished part must provide the best combination of all necessary factors at the lowest possible cost — a cost that must include machining, finishing and assembly where applicable.

Unique Production Method Combines Desirable Characteristics

The amount and form of carbon in ferrous metals is of prime importance. The carbon content of Malleable iron (2.00 to 2.60%) provides good fluidity at the pouring stage. Yet neither flake graphite nor combined carbon is present in finished standard Malleable iron.

As the photomicrograph of standard Malleable iron shows, the carbon has been transformed into temper carbon nodules in a matrix of ferrite during the heat-treatment given *all* Malleable iron castings. The result is a metal with a unique combination of high strength, toughness and machinability.

Pearlitic Malleable irons differ from standard, or ferritic, Malleable only in that a controlled amount of the carbon is combined with the iron to form a pearlitic matrix around the temper carbon nodules. This increases strength, hardness, wear resistance and modulus of elasticity, while retaining good ductility and machinability.

TENSILE PROPERTIES — A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons				
Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Elongation % in 2 in.	Ratio of Tensile to Yield %
Standard				
35018	53,000	35,000	18	66
32510	50,000	32,500	10	65
Pearlitic				
45010	65,000	45,000	10	69
45007	68,000	45,000	7	66
48004	70,000	48,000	4	69
50007	75,000	50,000	7	67
53004	80,000	53,000	4	66
60003	80,000	60,000	3	75
80002	100,000	80,000	2	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

TYPICAL BRINNELL HARDNESS NO. RANGES

Pearlitic Malleable Irons							
Designation	45010	45007	48004	50007	53004	60003	80002
B. H. N.	163-207	163-217	163-228	179-228	197-241	197-255	241-269

New Savings Result

From the wide range of properties obtainable, a Malleable iron may be selected that will most completely meet ideal design and functional requirements. Because of the great latitude of producible sizes, from a fraction of an ounce to hundreds of pounds, Malleable can be used for a wealth of applications.

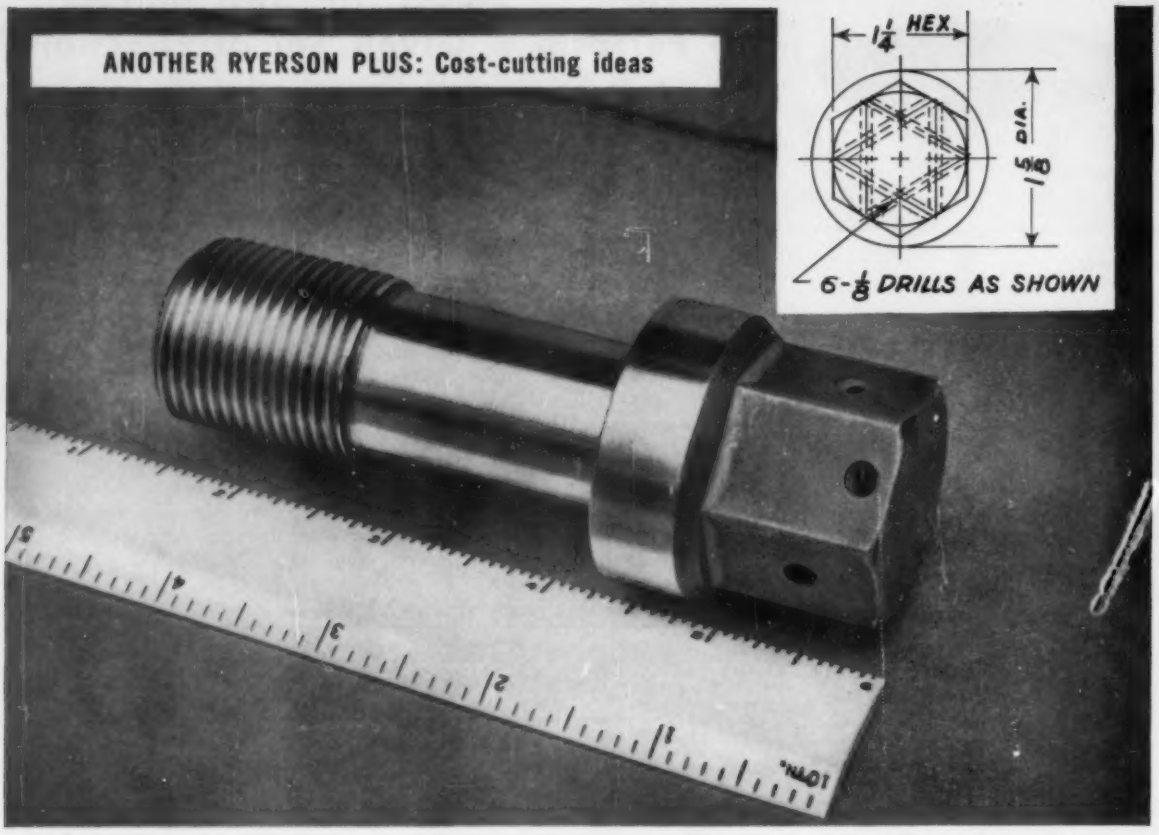
Malleable iron's economy is derived in two ways. First, the casting process is generally accepted as the most economical method of producing a finished part. Secondly, being the most machinable of all ferrous metals of similar hardness, cast or otherwise, Malleable iron castings provide exceptional economies in time, tool and power consumption.

Today's Malleable iron castings offer tremendous strength, uniformity, versatility and economy. The producers of Malleable castings are anxious to assist you in getting maximum "usability." Why not let their modern design, testing and production facilities work for you?

Send for Special Data Unit

Your copy of Data Unit No. 101 containing additional information on the benefits you can derive from Malleable iron castings is available from any member of the Malleable Castings Council. If you wish, you may direct your request to **Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.**

For more information, turn to Reader Service Card, circle No. 441



Rycut 40 drills cleanly, cuts down on tool wear and breakage.

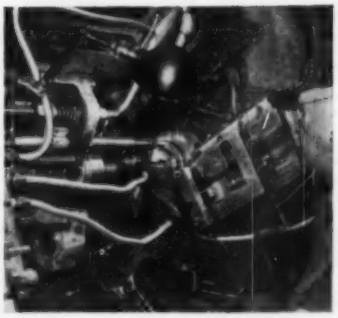
Rycut 40 alloy steel boosts production 30%, tool life 50%

Drilling piston pin bolt heads of AISI 4140 was a costly problem at Hyland Machine Co., Dayton, Ohio.

The job called for cross-drilling two holes in each face of the hex head (see diagram). A Ryerson specialist recommended new Rycut 40, the world's fastest machining alloy steel in its carbon range.

Here are the results, from Partner Forest Hyland: "We have cut down drill breakage. We have 15% fewer rejections. There is a marked improvement in finish, plus a comparable saving shown in milling the head of the bolt. Tool life on the automatic screw machines is 50% longer, total production is up 30%. Now we can produce this bolt at a competitive price."

There is a dependable, cost-cutting steel at Ryerson to meet every requirement. The Ryerson quality controls assure you of getting steel you can count on for dependable performance—every time. Ask your Ryerson specialist for help on your steel problems.



Six-spindle automatic screw machine producing piston pin bolts with cost-cutting Rycut 40.

RYERSON CERTIFIED QUALITY

RYERSON STEEL

Member of the HYLAND Steel Family

Principal Products: Carbon, alloy and stainless steel—bars, structurals, plates, sheets, tubing—aluminum, industrial plastics, metalworking machinery, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK · BOSTON · WALLINGFORD, CONN. · PHILADELPHIA · CHARLOTTE · CINCINNATI · CLEVELAND DETROIT · PITTSBURGH · BUFFALO · INDIANAPOLIS · CHICAGO · MILWAUKEE · ST. LOUIS · LOS ANGELES · SAN FRANCISCO · SPOKANE · SEATTLE

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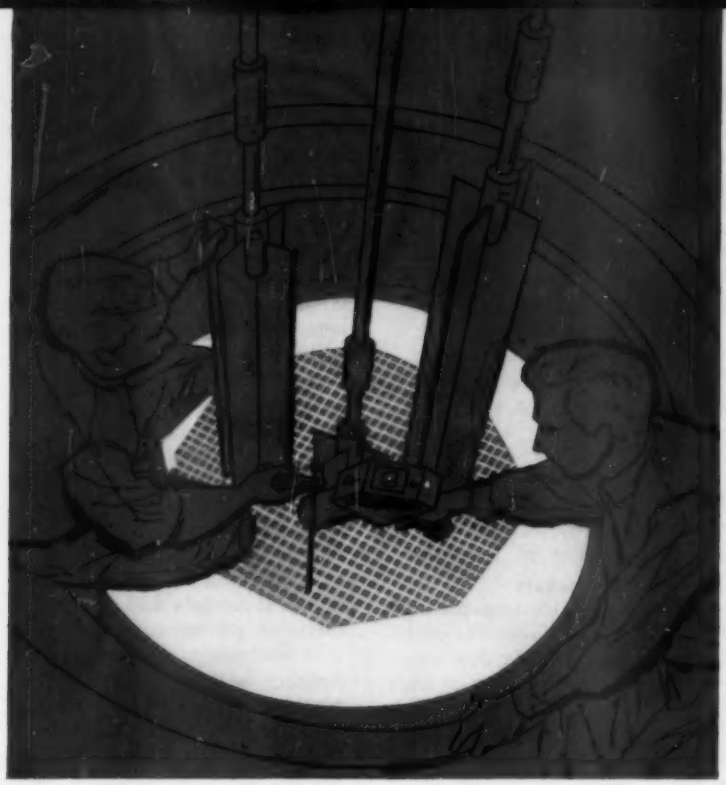


Right Materials Ease Maintenance of Nuclear Power Plants

This article tells how residual radioactivity can be minimized by selecting shielding materials carefully and by controlling the radioactivity of corrosion products.

by W. L. Fleischmann and S. L. Williams,
Knolls Atomic Power Laboratory *

■ Development of radioactivity in nuclear power plant materials can cause serious problems when maintenance and repair are required. Immediate entry into shielded areas for maintenance is limited by the level of radioactivity and its rate of decay. Also, there is a limit on the length of time maintenance personnel can remain in shielded areas without being exposed to excess radiation.

Favorable system design and coolant selection can play a large part in minimizing residual radioactivity (see box on p 75), but careful selection of structural materials is also extremely important. Wherever possible, materials should be selected that do not become radioactive by neutron capture or that develop only weak radiation of short duration. Specifically:

1. Minimize radioactivity of shielding by . . .

Access to the reactor can be greatly facilitated if the steels used for shielding do not contain elements with large cross sections which become highly radioactive isotopes upon neutron capture. The accompanying table shows the half-life of isotopes of elements that can be present in commonly used structural alloys. Tantalum, manganese and cobalt, in particular, occur quite frequently, and the quantity of these elements in structural alloys must be controlled to minimize radioactivity and increase accessibility.

. . . limiting tantalum

This element is usually found in columbium-bearing ores. Hence, tantalum content must often be limited when specifying columbium-containing steels. This has been done in the case of 348 stainless steel, which is identical to 347 stainless except that the tantalum content is limited to less than 10% of the columbium content.

. . . limiting manganese

Jones & Laughlin has developed a special low manganese steel for shielding applications which minimizes radioactivity and permits rapid access. The composition: 0.10 manganese, 0.20 carbon, 0.20 silicon, 0.20 titanium and 0.10% aluminum. Mechanical properties compare well with those of ordinary carbon steels.

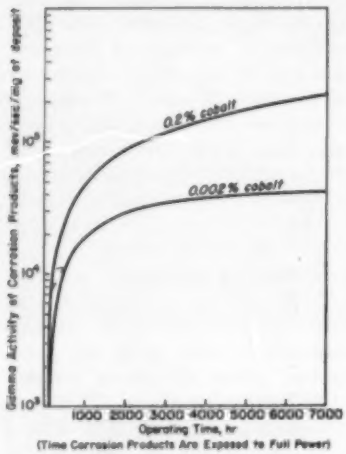
A manganese content of 1.5 to 2.0% is frequently specified in stainless steels to facilitate hot working operations and give lower rejection rates. Manganese in such quantities can cause radioactivity problems. However, special austenitic steels with a manganese content as low as 0.60% can be produced satisfactorily.

* *Operated for the Atomic Energy Commission by General Electric Co.*

HALF-LIFE OF ISOTOPES
(Of Elements That Occur in Nuclear Power Plants)

Element ↓	Cross Section, barns	Reaction	Half-Life
Chromium—Cr^{50}	16	Cr^{50} $(n\gamma)$ Cr^{51}	26.5 days
Manganese—Mn^{55}	13.3	Mn^{55} $(n\gamma)$ Mn^{56}	2.59 hr
Iron—Fe^{58}	0.9	Fe^{58} $(n\gamma)$ Fe^{59}	47 days
Cobalt—Co^{59}	18	Co^{59} $(n\gamma)$ Co^{60}	5.3 years
Nickel			
Ni^{58}	0.14[a]	Ni^{58} (np) Co^{58}	72 days
Ni^{60}	0.005[a]	Ni^{60} (np) Co^{60}	5.2 years
Copper—Cu^{63}	4.4	Cu^{63} $(n\gamma)$ Cu^{64}	12.8 hr
Hafnium—Hf^{180}	10	Hf^{180} $(n\gamma)$ Hf^{181}	50 days
Tantalum—Ta^{181}	22	Ta^{181} $(n\gamma)$ Ta^{182}	117 days
Tungsten			
W^{184}	2	W^{184} $(n\gamma)$ W^{185}	73 days
W^{186}	38	W^{186} $(n\gamma)$ W^{187}	24.1 hr

[a]Experimental determination of these cross sections is still in progress.



Effect of cobalt *content in 304 stainless steel on formation of radioactive corrosion products in high flux zone.*

. . . sometimes limiting nickel

The use of nickel need not be restricted in thermallized reactors because the activation of nickel by neutrons in the thermal energy range does not produce high energy or long-lived radioactivity. However, the effect of using nickel in high flux regions of fast flux reactors must be considered. High energy neutrons (fast flux range) produce a neutron-proton reaction with nickel to form cobalt-58 (Co^{58}). Cobalt-58 is not as long-lived as cobalt-60. However, it is radioactive, and because of the large amounts of nickel used in alloy steels it may be produced in sufficient amounts to create a radioactivity problem.

. . . limiting cobalt

Because of its considerably longer half-life, radioactive cobalt can create a considerably more serious accessibility problem than radioactive manganese. Cobalt occurs as an impurity in carbon and low alloy steels; in such steels a cobalt content of 0.012 to 0.02% is considered normal. Cobalt also exists in the austenitic steels and nickel alloys used in the reactor structure and cooling system. The effect of cobalt in these alloys is discussed in the following section.

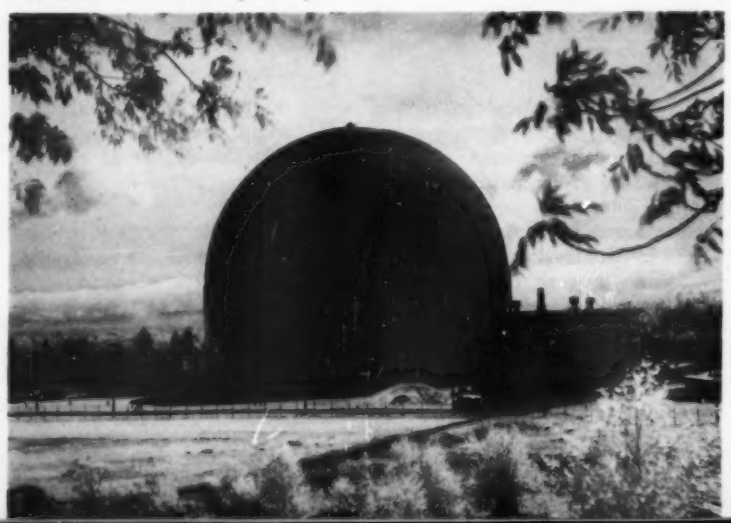
2. Control radioactivity of corrosion products by . . .

In general, radioactive corrosion products are formed by the corrosion of preactivated metal located in the neutron flux region, or by the activation of corrosion products that originate in the outflux portion of the coolant system and are carried into the neutron flux by the coolant. Radioactive corrosion products are transported to other parts of the system where they tend to accumulate on coolant pipe surfaces, remaining there even after the coolant is drained Allowing extra time for the products to decay in radioactivity is of little value, since the corrosion products usually contain significant quantities of cobalt-60 which has a 5.3-year half-life. The accompanying graph shows the influence of cobalt content on the total energy emanating from each milligram of corrosion products. The radiation level, and therefore accessibility time, depends upon the total amount and location of corrosion products deposited.

In determining accessibility, the designer has to estimate the approximate contribution of corrosion products from the various surfaces of the primary coolant system, and the probable time that the corrosion products will dwell in high flux zones. In order to minimize the formation of corrosion products, it is essential for the designer to know the effect various materials have on the formation of radioactive corrosion products. In general, there are three principal areas in which the choice of materials can affect the accessibility of the reactor. These are:

1. In-flux (area of high flux) structure.
2. Fuel element cladding.
3. Out-of-flux piping and com-

Experimental reactor *shown here is used to solve many materials problems associated with nuclear power plants.*



ponents, particularly the heat exchanger with its many tubes.

. . . using zirconium

A considerable amount of data has been compiled on the corrosion and irradiation of zirconium. All of these data indicate that zirconium and its alloys normally do not have any significant effect on the radiation level of corrosion products and can be confidently used for structural applications as well as fuel cladding. The desirable properties of these materials stem from the low release rate of zirconium corrosion products and the low capture cross section and soft gamma energies of the irradiated zirconium nuclides.

. . . limiting cobalt

Because of its long half-life and high energy gamma radiation, cobalt, when used in steel, can create a serious accessibility problem. Consequently, the amount of cobalt contaminants must be kept as low as possible.

Keeping cobalt low is difficult to accomplish. Cobalt exists in nickel in varying amounts even after refining. Cobalt is also present in other metals used in producing steel; basic pig iron, for example, contains about 0.01% cobalt, and ferrochrome contains about 0.10% cobalt.

A varying amount of cobalt can be expected in the 300 stainless steels. At present cobalt contaminants of the 300 stainless steels are usually below 0.20%, but this figure can still be too high for some nuclear applications.

To assure low cobalt content, the stainless steels should be made with electrolytic nickel and selected ferrochrome additions. It is also advisable to make the furnace charge without stainless steel scrap additions because high temperature alloy scrap may contain cobalt. If such procedures are followed, a maximum content of 0.05% cobalt can be expected. If cobalt content must be kept below 0.05%, it may be necessary to use a special heat containing carbonyl nickel, ingot iron, and electrolytic chromium and manganese.

Should stainless steel be used for fuel cladding, a steel with the lowest possible cobalt contamination appears advisable, since the cladding is exposed to the highest fluxes in the reactor. Because of the difference in corrosion rates between a sodium-cooled and a pressurized water reactor, the steel for a sodium-cooled reactor may have a higher cobalt content.

Current operations indicate that the formation of radioactive corrosion products, particularly in the later stages of plant life, can be reduced if cobalt-free steels are used in coolant piping and components, and even in the boiler tubes alone. One inexpensive approach is to use carbon steel for the boiler tubes. It has been reported that the total residual alloy content of a number of elements in carbon steel (including cobalt) does not exceed 0.15%. However, it has been suggested that if radioactive cobalt is already present in the coolant, heavier radioactive deposits can be expected on carbon steel surfaces than on stainless steel surfaces.

This article is based on a paper presented before the Nuclear Engineering and Science Conference, Mar '58, Chicago.

Two Other Ways to Promote Accessibility

System design: avoid dead ends

Careful attention to system design is essential in order to prevent deposition of radioactive corrosion products which are carried away from the core area. It is obvious that any crevices and stagnant volumes are bound to fill up with corrosion products which have a high level of radiation. In one nuclear reactor it was found that the radiation level after shutdown was six times higher in a dead-ended horizontal branch of a vertical section connected to the main pipe than it was in the main pipe itself. Also, radiation was ten times higher in a dead-ended horizontal tee connection off the horizontal main pipe than it was in the main pipe. As expected, a vertically mounted branch showed the same low radiation level as the main pipe.

In short, the accumulation of localized corrosion products can be lowered by:

1. Minimizing the number of dead-end lines. Wherever possible, design all necessary dead-end lines with a vertical take-off from the top of the pipe. Avoid bottom take-offs.

2. Plugging bottom drains during operation so that the volume of dead space in the drain is reduced.

3. Avoiding stagnant areas and pockets. Wherever they do occur, provide separate means for draining and flushing.

Coolant selection: water is better

Without considering the presence of any radioactive corrosion products or coolant impurities, accessibility with respect to the coolant is limited only by the induced radioactivity of the coolant, which is a function of its half-life and cross section. In the case of water, the nitrogen-16 (N^{16}) created by a neutron-proton reaction (a neutron-proton reaction designates the capture of a neutron with a proton being emitted) from oxygen-16 has a half-life of only 7.35 sec. The nitrogen-16 has sufficient radioactivity to require shielding during operation; however, because of its short half-life it does permit access almost immediately after shutdown.

On the other hand, access is delayed if the coolant is sodium which, by a neutron-gamma reaction (a neutron-gamma reaction designates the capture of a neutron with the release of gamma radiation), changes from sodium-23 to sodium-24 ($Na^{23} \rightarrow Na^{24}$). Sodium-24 has a half-life of 14.8 hr, and repairs and maintenance can only be made if the coolant is drained and flushed, or allowed to decay.

A status report on heat, wear and corrosion resistant

Molybdenum Coatings

How Good Are They? Where Can They Be Used?

■ Because of their unique combination of properties, molybdenum coatings have been adopted for a number of industrial products in the past few years. This article tells what you should know about the properties of molybdenum coatings and where they can be used. It also summarizes the latest information on application techniques.

by H. W. Schultze, R. R. Freeman and J. Z. Briggs,
Climax Molybdenum Co., Div. of American Metal Climax, Inc.

Properties of molybdenum coatings

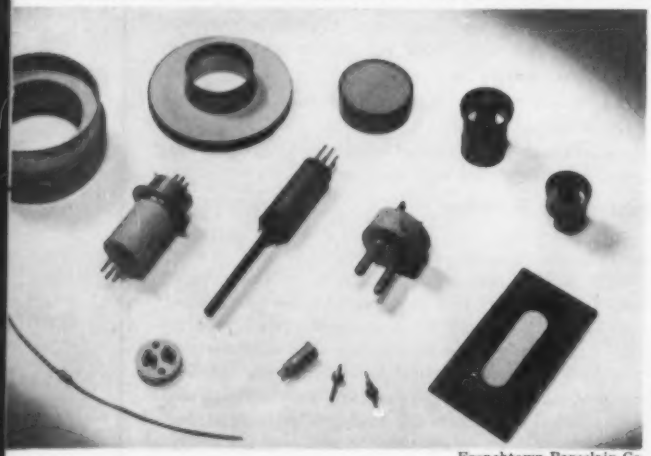
Physical properties

In general, the physical and nuclear properties of molybdenum coatings are similar to those of solid molybdenum. A notable similarity is their low coefficient of thermal expansion; for molybdenum coatings the coefficient is 2.7 x 10^{-6} per °F (32 to 200 F), whereas for solid molybdenum it is 3.0 x 10^{-6} per °F (room temp).

Both the thermal and electrical conductivity of molybdenum vary somewhat with density and constituents. The density of sprayed molybdenum coatings is about 85 to 95% that of solid molybdenum. Density can even be further increased by sintering, particularly if small amounts of nickel, cobalt or iron are added to produce a liquid phase during sintering. Electrophoretic coatings have a density of about 90%.

Sprayed molybdenum coatings have low shrinkage stresses; this is sometimes the deciding factor in selecting sprayed molybdenum over other sprayed metals. Also, the moderate thermal neutron cross section of molybdenum coat-

Molybdenum coatings can be produced in many ways. Below are two commercial processes . . .



Frenchtown Porcelain Co.

***Ceramic metallizing** is widely used on electronic parts to provide a ceramic-to-metal seal. The coating also promotes brazing with a wide variety of alloys.*

***Spraying** is widely used to build up mismachined surfaces and to provide high wear resistance.*

Metallizing Engineering Co., Inc.

ings — about 2.4 barns — make them more desirable for nuclear applications than some other metal coatings.

Molybdenum carbide coatings deposited by the carbonyl process have properties quite different from those of molybdenum metal. The special properties of these coatings can be used to advantage in electronic components such as electrodes and grids; they combine low electron emissivity with good resistance to softening at high temperatures.

Adhesion

Excellent adhesion is a characteristic of almost all molybdenum coatings. In most cases a limited amount of diffusion is required for good bonding. Because of insufficient diffusion many of the coating methods will not give an adherent coating on copper. Conversely, flash coatings of nickel or cobalt are often used on iron and steel to minimize excessive diffusion which can cause the formation of a brittle intermetallic phase. Also, formation of molybdenum carbide on the base metal in the carbonyl process produces a nonadherent coating which is likely to spall off. Therefore, plating conditions must be adjusted to give a low carbon content in the layer next to the base metal.

Molybdenum-plated parts can generally be deformed considerably without peeling. The good bond strength of electrophoretic coatings is demonstrated by their resistance to thermal cycling and shock. Sprayed coatings have bond strengths of 3000 psi and higher. Also, vapor deposited coatings (carbonyl process) have withstood such tests as:

1. Compression of 20% on ½-in. hardened steel specimens coated with 0.005 in. of molybdenum. Compression was produced parallel to the surface and in no case did cracking or shearing occur.
2. Bend of 90 deg on specimens ⅛ in. thick with the coating on the outside. Cracking always occurred under the imposed tensile stresses, but there was no spalling or loss of bond.
3. Shear; bond strength was found to be 54,000 psi parallel to the bond.

Hardness

Hardness of molybdenum coatings varies widely and depends largely on the degree of purity. High purity deposits are relatively soft; deposits containing large amounts of carbon are hard. Following are some typical Vickers hardness values: solid molybdenum (recrystallized) — under 200; molybdenum plate (carbonyl)—300 to 1560; molybdenum plate (pentachloride)— 230 to 350; sprayed molybdenum (macrohardness)—400.

Ductility

Ductility of a molybdenum coating depends on its carbon and oxygen content as well as its hardness. Ductility usually varies with hardness but this is not always true. The presence of molybdenum carbide in carbonyl deposits, for example, produces brittleness with no appreciable increase in hardness.

Elongation values as high as 10.8% have been reported with stripped coatings vapor-deposited from molybdenum pentachloride. These coatings, developed at Massachusetts Institute of Technology, were specially designed to have a very low carbon (0.003%) and oxygen content, and were reduced 85% by rolling prior to vacuum annealing at 3800 F for various periods.

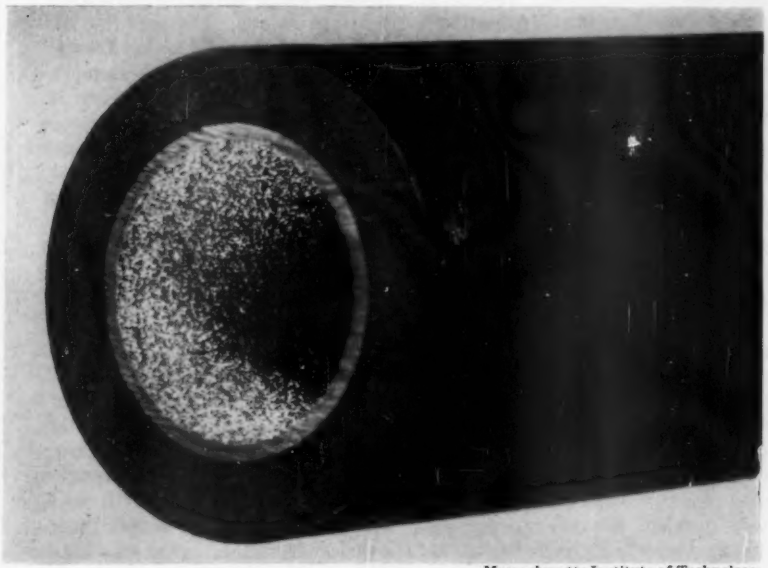
Strength

Strength of a molybdenum coating is closely related to deposit structure. Vapor-deposited and other coatings with columnar structures have poor lateral strength. Molybdenum plated on steel by the carbonyl method has an average shear strength of 100,000 psi in the plate parallel to the bond; shear strength normal to the bond is only 25,000 psi because of the columnar crystals.

Sprayed molybdenum coatings have low strength parallel to the layers of the deposit. The strength of sprayed molybdenum is adversely affected by oxygen content. Normally, sprayed coatings have tensile strength of about 7500 psi and 0.03% extension under load.

Tests on coatings deposited by the MIT pentachloride method described above have shown a stress

. . . and an experimental one.



Massachusetts Institute of Technology

***Vapor deposition** was used to plate molybdenum 0.050 in. thick on inside of this graphite tube. A molybdenum-carbide layer formed between the plate and the graphite appears to strengthen the bond.*

of 42,000 to 69,000 psi and an elongation of 6.6 to 11.3% at the fracture point. Higher strength of the pentachloride coatings is believed to be the result of their superior structure and lack of longitudinal flaws. The strength values are reported to be four times higher than those obtainable with comparable commercial parts made from molybdenum metal powder.

Wear resistance

Molybdenum coatings have extremely good wear resistance under a variety of conditions. Sprayed parts, especially, show very high wear resistance when running against bronze and babbitt. In many cases the life of the softer mating surface is also increased.

Similar results have been obtained with vapor-deposited coatings, especially on titanium. A hard steel ball (Rockwell C65) can produce appreciable wear and galling on both unlubricated and lubricated titanium. However, titanium that is plated with molybdenum by the carbonyl process can withstand thousands of strokes without lubrication. It is claimed that a good wear resistant molybdenum coating can be applied to an annealed titanium alloy in 1 or 2 hr without changing the structure or properties of the metal.

Corrosion resistance

Corrosion resistance of a molybdenum coating is markedly influenced by its structural soundness. A porous coating, such as sprayed molybdenum, does not give much protection in aqueous media. Even if the coating is not corroded, the base metal can be attacked through the pores.

The corrosion resistance of dense coatings, such as electrophoretic and vapor-deposited plates, appears to be similar to that of solid molybdenum. Thus, high resistance can be expected to such reducing acids as hydrochloric, hydrofluoric, sulfuric and phosphoric, even at high concentrations and temperatures.

To resist corrosion by liquid metals, molybdenum coatings do not have to be perfectly dense and nonporous. Most molybdenum coatings have good resistance to liquid sodium, as well as many other liquid metals such as bismuth. However, some British tests show that sprayed molybdenum can disintegrate in liquid sodium when the liquid metal penetrates the coating and destroys the adhesion between the molybdenum and the base metal.

All molybdenum plates have the same susceptibility to oxidation as solid molybdenum. Consequently, plates cannot be used in air or oxidizing atmospheres at temperatures over 750 F unless they are treated with some type of protective coating.

Where molybdenum coatings can be used

The unusual combination of properties offered by molybdenum coatings has resulted in a number of interesting applications. Some of these have been quite successful commercially, whereas others are still in an advanced stage of development.

Electronic components

In certain types of electronic tubes, such as ultra-high-frequency and very-high-frequency tubes, it is often necessary to use ceramics rather than glass. Ceramic tubes are stronger and last longer, and they can be operated at higher power, frequency and temperature. Since the ceramic forms part of a vacuum envelope, a good ceramic-metal seal is needed. A metallized molybdenum coating (molybdenum-manganese method) has proved extremely satisfactory in effecting such a seal and has met rigid requirements of vacuum tightness, strength and resistance to heat shock.

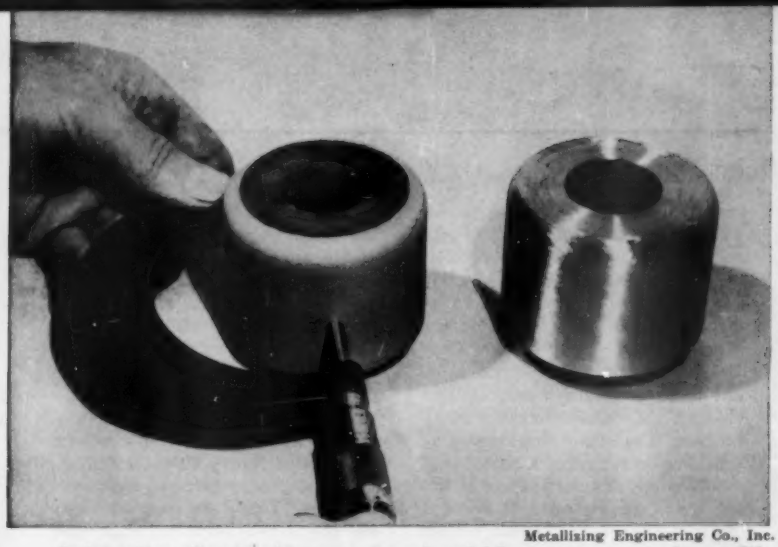
In another application the Bell Telephone Laboratories developed a magnetron ring with an interior coating vapor-deposited from molybdenum hexacarbonyl. This ring was designed so that an oscillating current could flow through the copper anode while the molybdenum plate served to dissipate the heat of electron bombardment. On the basis of encouraging tests at high output a machine was developed for mass production molybdenum plating. However, other factors caused this project to be discontinued.

Automotive uses

One of the most interesting applications of molybdenum coatings is their use in experimental all-aluminum automotive engines. Ordinarily, a conventional aluminum piston does not function well when bearing against an aluminum cylinder wall. However, this problem has been overcome by coating the walls with a sprayed molybdenum bond coat and a sprayed steel topcoat. This composite coating has provided a longer life than that obtainable with conventional engines. Favorable results have also been obtained when using molybdenum coatings alone, particularly on cylinder walls and brake drums. Tests on a portable aluminum gasoline engine have caused a breakdown in the chromium plate on cylinder walls after less than 400 hr, whereas molybdenum-sprayed parts showed little or no wear after 4000 hr.

Mismachined automotive crankshafts are salvaged by spraying with molybdenum. Crankshafts are sprayed with 0.010 to 0.040 in. of molybdenum before grinding to size. Sprayed shafts surpass all quality requirements and have exceptionally fine bearing surfaces. American Motors Corp. began this type of salvage operation in 1950 and by 1956 it was estimated to have saved them over $600,000.

Sprayed molybdenum coatings have also proved extremely effective in lengthening the life of



Metallizing Engineering Co., Inc.

***Automotive die punches** use sprayed molybdenum to promote longer life. Part on left is in as-sprayed condition; part on right has been finished and is ready for use.*

automotive production equipment. In producing flanges for the ends of Buick axle housings, a forming punch had a life limited to 200-300 pieces because of loading and welding of metal on the punch. Various expedients, including the use of tool steel, carbides and chromium plate, were tried without much success. The problem was eventually solved by using a sprayed molybdenum coating. The punches can now produce 30,000 to 40,000 parts before they have to be resprayed.

Aircraft uses

Sprayed molybdenum coatings are used on aircraft engine ball-joint couplings to prevent excessive wear. Of all the hard surfacing methods considered, only sprayed molybdenum could be applied at a temperature low enough to prevent distortion and loss of strength of the base metal. Sprayed couplings have shown no sign of wear or fretting corrosion after 150 hr of engine testing. The coatings are now specified for overhaul salvaging as well as for new parts

Another promising, but still experimental, aircraft use for molybdenum coatings is arresting hooks. This application came about because the hard facing (a nickel-base alloy with dispersed chromium-boride crystals) used on arresting hooks had a tendency to seize with the wire because of the high frictional temperatures generated during engagement. To alleviate this problem both vapor-deposited and sprayed molybdenum coatings were tried instead of the hard facing. Of the two, the sprayed molybdenum proved to have better resistance to severe impact and high pressure abrasion. The coating was easy to apply, did not fail in any way, and produced no detrimental effects on the arresting wire. Unfortunately, further tests on this promising application could not be completed because the development contract expired.

Armament

Molybdenum coatings have been used experimentally as gun liners. Originally, solid molybdenum was selected as an experimental replacement for steel gun tubes because of its high strength and its resistance to heat checking and erosion by hot gases. However, because solid molybdenum was unobtainable in large sizes, the Ordnance Corps sponsored work on molybdenum plating. Tests indicated that various types of molybdenum coatings had high quality, but firing data have not been published by Watertown Arsenal.

Nuclear reactors

Molybdenum coatings have been used commercially and experimentally in many nuclear applications. However, service results have often been unobtainable because of security restrictions.

Molybdenum coatings have been tried in experimental fuel elements both for corrosion protection and as a carrier for fissionable material. In one design beryllia moderating cores were to be coated with a fissionable material in a molybdenum matrix, the molybdenum serving as a diffusion barrier and fuel carrier. Heated and densified molybdenum coatings applied to beryllia have been found to maintain a good bond after 100 hr at 2000 F, followed by 15 thermal cycles between room temperature and 2000 F. Shrunk-on molybdenum rings could not maintain adherence after similar testing.

Molybdenum coatings have also been tried in pin-type metallic fuel elements. Each element is composed of a base wire of molybdenum, a fuel layer of 20 uranium dioxide-80% molybdenum, a diffusion barrier of pure molybdenum, and an outer layer of chromium for corrosion protection. The diffusion barrier is applied by electrophoretic deposition and has satisfactory bonding and density.

In addition, electrophoretic coatings have been used on Inconel shafts in an experimental application requiring good bearing properties and resistance to corrosion by fused salts. Another application in the research stage uses molybdenum to coat graphite and stainless steel to make them impermeable to hydrogen and other gases.

Other uses

Sprayed molybdenum coatings are used in a number of applications requiring high wear resistance. In some of these uses, sprayed molybdenum was originally adopted for salvage operations but, because of the excellent performance of the coatings, is now frequently specified for new parts. A good example is the grinder spindle shaft used in the production of close-tolerance, split-sleeve bearings. Unprotected shafts can fail in as little as 4 hr, whereas molybdenum-sprayed

How Molybdenum Coatings Are Produced

As shown in the accompanying table, molybdenum coatings can be produced by a wide variety of methods. These methods shown are only those that produce a pure molybdenum or molybdenum alloy coating. They do not include molybdenum-clad sheets or processes such as solid-phase molybdenizing and salt bath case hardening where the maximum molybdenum content of the case is under 50%.

The most important factors in selecting the best coating method for a given application are the type of material to be plated, maximum processing temperature, rate of deposition, and the equipment needed. In most cases consideration of these factors will limit the choice to one or two coating methods.

Ceramic metallizing

Ceramic metallizing (not to be confused with conventional metal spraying, or metallizing) is a specialized process that is used to produce ceramic-metal seals in electronic equipment. Originally, in the so-called Telefunken method introduced in Germany during World War II, molybdenum alone was used. However, General Electric later developed a more adaptable molybdenum-manganese modification. The coating is applied by brushing or spraying a mixture of molybdenum and manganese powders (in a weight ratio of about 4 to 1) on the ceramic, which is then fired in oxygen-free hydrogen at about 2350 F for 15 to 60 min. The metallized ceramic is then plated with nickel or copper, refired in hydrogen at 1830 F for 10 min, and subsequently assembled with metal parts by brazing.

Metal spraying

An ordinary sprayed or metallized molybdenum coating was originally recommended as a bond for other sprayed metals because of its ability to provide a simple and dependable bond without requiring any special surface preparation other than a thorough cleaning. However, it has now become evident that sprayed molybdenum coatings can provide high wear resistance when used alone.

Sprayed molybdenum coatings are applied simply by using a wire-type metallizing gun and oxyacetylene gas. There are no limitations on the size of parts that can be coated, although molybdenum spraying is slower than other types of metal spraying. Spraying efficiency (metal deposited) is about 87%. Sprayed molybdenum is generally unmachinable and must be ground to final dimensions.

Electrophoretic deposition

Electrophoretic deposition offers certain definite advantages over

MAJOR TYPES OF MOLYBDENUM COATING PROCESSES—A SUMMARY

Type ↓	Max Temp in Processing, F	Deposit Thickness, in.	Rate of Deposition	Materials That Can Be Coated
COMMERCIALLY AVAILABLE COATINGS				
Ceramic Metallizing[a]				
Molybdenum	2400-2900	0.001	—	Ceramics (especially high alumina materials), sapphires
Molybdenum-Manganese	2280-2460	0.001	—	
Metal Spraying	Up to 500	0.0015-0.002 for bonding; 0.010-0.040 for wear resistance	5-6 lb/hr (0.010 in. on 13-15 sq ft)	Successful on all irons and steels, nickel alloys, magnesium and most aluminim alloys. Only fair results on lead, tin, zinc, galvanized iron. Unsatisfactory for copper and copper alloys, chromium plate, high-silicon iron. Use on glass and ceramics limited by their resistance to thermal shock.
COATINGS IN ADVANCED DEVELOPMENT STAGE				
Electrophoretic	2190	0.001-0.01	0.002 in. in 20 sec	Steels, nickel alloys, other metals that can withstand the high processing temperature. Ceramics can be coated if graphite (burned off during sintering) is added to provide electrical conductivity
Vapor Deposition				
Molybdenum Hexacarbonyl	800-1450	0.001-0.005	0.0005-0.003in./hr[b]	All metal, ceramics, glass, other vitreous materials, graphite. Base material does not need to be a conductor. Iron and steel preferably given flash coat of nickel or cobalt before molybdenum plating
Molybdenum Pentachloride	1650-2000	0.003-0.10	0.005-0.02 in./hr	
COATINGS IN LABORATORY DEVELOPMENT STAGE				
Electrodeposition	1100-1650	Up to 0.02	0.001-0.002 in./hr	Iron, steels, copper. Silver or nickel strike required. Nickel strike can be deposited by electroplating or electroless process
Sputtering	Low	0.0001 max	0.00001 in./hr	All
Vacuum Evaporation	Low	0.0001 max	0.00005 in./hr	All

[a]Specialized process name not to be confused with conventional metal spraying, or metallizing.
[b]Rate can be increased considerably by using large pumps. Plans have been disclosed for a commercial unit to plate small copper magnetron rings at a rate of .030 in. per hr.

electrodeposition. The process is rapid and economical, has high throwing power, and permits a large amount of material to be deposited uniformly over irregular shapes.

Electrophoretic coatings are produced from a dispersion of finely divided molybdenum in a nonaqueous solvent. A sintering step in a reducing atmosphere at about 2200 F transforms the deposits into a homogeneous coating. The coating may be densified before or after sintering to provide an impermeable coating. Hydrostatic pressing at 50,000 to 100,000 psi has been found most efficient. Where heavy coatings are needed it may be desirable to build up successive layers with intermediate sintering and densification.

Electrophoretic molybdenum coatings machine well and do not peel from the base metal. At present the size of parts that can be coated is limited to about 1¾-in. dia by 14-in. length; however, newer equipment is expected to accommodate diameters up to 5 in.

Vapor deposition

Vapor deposition produces molybdenum coatings with high penetration on parts of any size or shape. It is a comparatively fast method and can be performed in a continuous operation. The actual process is relatively straightforward, but considerable engineering know-how is needed for efficient operation.

Vapor deposition is accomplished by forcing a plating gas containing a volatilized molybdenum compound past the heated base metal in a partially evacuated system. The molybdenum can be deposited from either molybdenum hexacarbonyl or molybdenum pentachloride. The hexacarbonyl is decomposed by heat and can be used alone or with hydrogen as a carrier. The pentachloride is reduced by hydrogen, and helium or argon may be used as a carrier gas to eliminate premature reduction and give closer control.

A comparison of the carbonyl and pentachloride processes shows that, for the same pumping capacity, the rate of decomposition is considerably lower for the carbonyl than for the pentachloride. However, carbonyl plating can be carried out at lower temperatures. It is easier to obtain a ductile, machinable deposit from the pentachloride than from the carbonyl. On the other hand, the carbonyl process can be modified slightly to produce deposits of molybdenum carbide, molybdenum sulfide or molybdenum boride.

Molybdenum pentachloride has been used (on a laboratory scale) to continuously plate iron, copper and molybdenum wire in lengths up to 1000 ft. This wire can be spooled and moderately deformed without damage. The process has also been used to produce a 0.004-in. molybdenum plate on the inside of steel tubes 1⅝ in. in i.d. and 20 in. in length.

Electrodeposition

Electrodeposition of molybdenum has proved comparatively difficult. Conventional deposition methods generally produce mixtures of molybdenum oxides, or extremely thin, nonprotective films of molybdenum. The only method that has sucessfully produced massive deposits is the National Bureau of Standards' fused salt process. However, this method has not been applied commercially.

Nevertheless, alloys containing up to 50 or 60% molybdenum combined with iron, nickel or cobalt can be deposited from citric acid baths. The low molybdenum alloys hold some promise, but the mechanical properties of alloys with over 25% molybdenum have not been good. The only high molybdenum electrodeposits used commercially are the so-called moly blacks, which are a mixture of molybdenum and nickel oxides. These plates are principally used to protect and decorate zinc and cadmium.

Sputtering and vacuum evaporation

Both of these methods are still in the laboratory stage. Sputtering is a relatively complex process involving disintegration of a cathode under bombardment with ionized gas molecules. An extremely long time is required to produce a very thin film.

The evaporation process is not very practical for depositing molybdenum because the material's boiling point is too high and its vapor pressure is too low.

spindles last for over 18 months. Because of the cost savings involved, sprayed molybdenum shafts are now specified as original equipment. Similarly, sprayed coatings are now specified for new lathe ways as well as for salvage operations.

Another wear resistance application is the use of sprayed molybdenum on large fan blades used in a coal dust extractor plant in Great Britain. To determine the effectiveness of the coating, a small area near the base of the blade where wear was most severe was sprayed with 0.003 to 0.005 in. of molybdenum. After 1500 hr of operation, the sprayed area showed hardly any sign of wear whereas the rest of the blade was reduced to wafer thickness.

Future uses

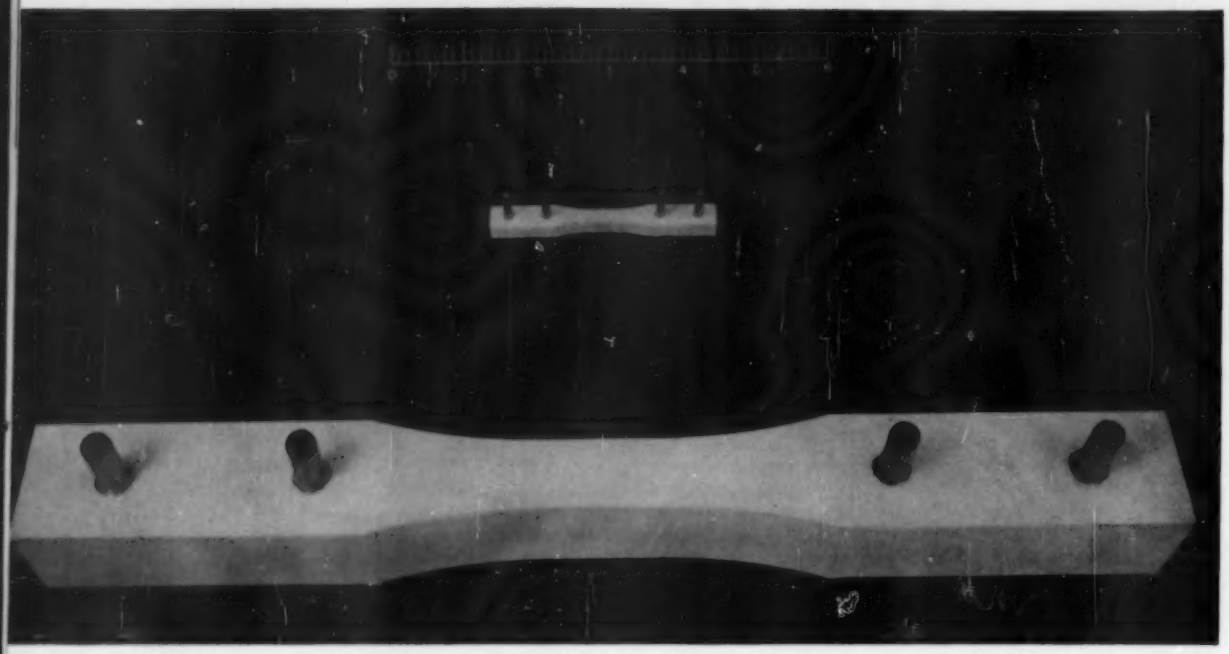
One of the most important future uses that has been suggested for molybdenum coatings is as interior platings to reduce erosion and corrosion in nonoxidizing, high temperature, high pressure chemical systems. A typical example would be a high temperature polymerization system where extreme flow velocities could cause erosion. Specific parts that would lend themselves to such protective plating include valves and valve trim, tubing and piping, heat exchangers and reactor vessels.

Some relatively unexplored fields that offer encouraging possibilities are the: 1) production of inexpensive carbide tools and dies by using controlled thermal decomposition of hexacarbonyl to deposit hard molybdenum carbide coatings, 2) use of molybdenum or molybdenum carbide coatings on electroforming dies and wear plates, 3) use of vapor-deposited molybdenum sulfide films as lubricating surfaces, 4) siliconizing of molybdenum deposits to provide oxidation resistance, and 5) of electroless molybdenum plating.

References

Within the past few years a considerable number of articles have been published on molybdenum coatings, and the authors have compiled an extensive bibliography. Copies of this bibliography can be obtained by writing to Dr. J. Z. Briggs, Director of Technical Information, Climax Molybdenum Co., 500 Fifth Avenue, New York 36, N. Y.

Section size affects strength . . .



***Two specimens** here differ in volume by a ratio of about 125 to 1. Pins in ends are inserted to reduce effect of friction between specimen and load during test.*

Designing with Brittle Materials

EFFECT OF SIZE ON FRACTURE STRENGTH

Material and Type of Test	Relative Volume	Mean Fracture Strength, psi	Standard Deviation, psi	No. of Specimens
PLASTER				
Tension	1	1,265	195	35
	64	975	165	45
Bend	1	1,840	225	45
	125	1,420	210	35
Torsion	1	1,540	285	80
	125	1,135	195	35
PORCELAIN				
Torsion	1	32,500	3,200	10
	120	28,300	2,470	20
TiC CERMET				
Bend	1	135,000	13,810	6
	2.4	120,500	14,120	5
	4.6	102,800	3,300	5

Source: *Salmassy et al.*

When you design with materials like ceramics you must face the problem of brittle failure. Here are concrete suggestions that will help you achieve successful product designs.

by Winston H. Duckworth,
Chief, Ceramics Div., Battelle Memorial Inst.

. . . a promising statistical correlation

Ceramic materials, at least on an atomistic scale, are populated with defects or discontinuities of some sort. According to *Griffith*, fracture occurs because of stress concentration at a defect. Once separation begins, localized stresses at the tip of the crack increase as the crack lengthens. Thus a crack can propagate without additional load.

Under these conditions, stress at fracture, as measured by mechanical tests (the ratio of applied load to area), is not necessarily an index of the strength of each elemental volume of the material, but a measure of the strength of the *weakest* elemental volume. Since the number of defects would tend to increase with increasing specimen size, the probability of there being a more serious defect would also increase. Thus, observed stress at fracture is dependent on chance. The probability of fracture at any stress is dependent on the volume of material present and the perfection of the material.

HOW PREDICTED DATA COMPARE

Material and Type of Test	Relative Specimen Size	Mean Fracture Strength, psi	
		Experimental	Predicted by Weibull's Relationships*
PLASTER			
Bend	Large	1,420	1,310
	Small	1,840	1,800
Tension	Large	975	1,000
	Small	1,265	1,320
PORCELAIN			
Bend		37,200	30,000
Tension		27,050	25,800

*Predicted from strengths obtained on two sizes of torsion specimens.
Source: *Salmassy et al.*

Assuming that materials contain weak places in a statistical distribution and that the materials behave like chains, breaking at their weakest link, *Weibull* has developed expressions relating changes in strength to size changes. By considering the tensile stress acting in each elemental volume, he has also derived relationships among strengths derived from bend, tension and torsion tests.

The accompanying table compares strength data from preliminary, carefully controlled experiments at Battelle with those predicted by Weibull's expressions. The results are encouraging and indicate that if fracture strength data are to be used to specify materials and to successfully design with them, the statistical approach warrants attention.

■ Conventional mechanical design principles cannot be applied with confidence to brittle materials such as ceramics. In designing with ductile metals, laboratory-determined yield strength values plus a selected safety factor provide a safe structural design. With ceramics, which have no yield point and fail in a brittle manner, no alternative to trial-and-error design exists. A successful mechanical design with brittle materials is more likely, however, if certain considerations are properly understood. These considerations lie in the areas of 1) component design, 2) property data, and 3) material quality.

Adjusting component design

The problem of brittle failure in any given ceramic design can be minimized in several ways. Each way tends to make the material fail by deformation rather than brittle fracture, if overloaded.

1. Increase operating temperatures—Most materials become less resistant to plastic flow as temperatures increase. For example, experiments at Battelle have shown that certain ceramic specimens could always be fractured by temperature-induced stresses within the specimens if the highest temperature the material reached was below about 1900 F. When the temperature level was raised, the ceramic could be made either to flow or fracture, depending on the rate at which stresses were applied.

2. Apply loads slowly—Relatively speaking, flow requires time for initiation, whereas fracture does not. Thus, slow loading tends to increase plastic flow. In the experiments mentioned above, applying the stress slowly at the higher temperature level, caused the specimens to flow with no apparent failure. This flow relieved stresses that otherwise would have fractured the material. Rapid loading caused fracture.

3. Increase the ratio of shear-to-tensile stress—An increase in shear stress may shift the mode of failure from brittle to ductile. Reducing tensile stresses, of course, lessens the chance of brittle fracture. Notches raise the ratio of tensile-to-shear stress; thus notches and other stress concentrators should be eliminated.

4. Increase the stress level at which fracture will occur—The stress level at which fracture will occur in a given ceramic material can be increased in several ways. Stress concentrations from sources such as rough bearing surfaces or poor alignment between parts should be avoided, since materials that lack ductility cannot deform readily to distribute stresses evenly except by fracturing. Replacing large members with sev-

eral smaller ones may increase the stress required to fracture the composite or assembly, since smaller parts have higher fracture strengths than larger ones. This factor is discussed in more detail later.

Interpreting property data

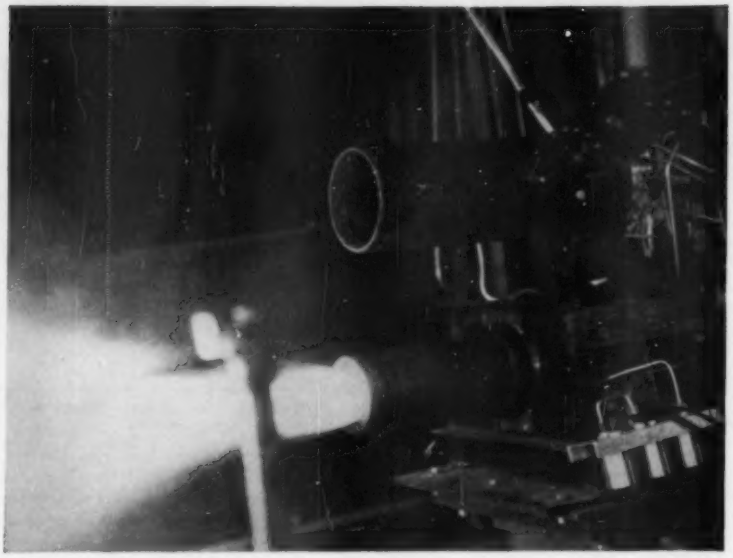
Present knowledge does not permit the use of fracture strength data in mechanical design calculations. Actual or closely simulated service trials are the only way to tell whether a design using a nonductile material will withstand the load.

Ceramic strength data provide only a general index of the relative fracture resistance of different materials. In order to properly evaluate comparative strength data, the designer or engineer should be aware of what the particular test actually measures, and how test results can be used. It is also important to be aware of the shortcomings of the various tests and the effect of test variables on test results, since such effects are directly related to the nature of the material.

Bend tests appear preferable for ceramics. Compression, torsion and direct tensile tests can also be made, but alignment and bearing-surface problems in nonductile materials are severe enough to drastically limit their use.

In comparing bend test results for different materials, variables such as specimen size, strain rate and distribution of values for a given material may be so important as to actually change the relative order of strengths for different materials.

Specimen size—The table on p 83 shows the effect of size of specimen as well as type of test on strength of three different ceramic materials. In each case mean fracture strength decreases with increasing size. This effect is believed to be due to the fact that fracture is initiated by stress concentrations at a defect within the material. The larger the specimen, the greater the probability of a more severe defect occurring within the specimen. A statistical method of correlating strength and specimen size appears promising (see accompanying box), but more work is needed before its utility can be fully evaluated.



Heat resistance *makes ceramics very useful for structures if brittleness can be designed around.*

Strain rate—Observed strengths of ceramics increase with increasing strain rates, though there is no accepted quantitative correlation between the two. In experiments at Battelle, strengths of plaster and of porcelain have been increased about 40% by increasing speed of application of breaking stress over the range obtainable on laboratory testing equipment. In general, then, slow loading tends to bring about

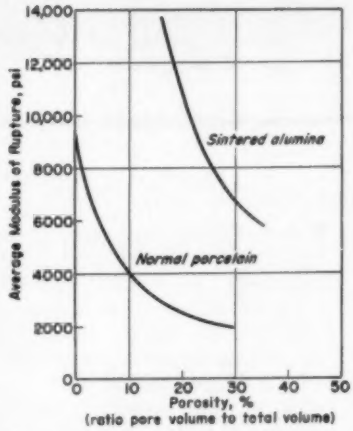


Fig 1*—Porosity vs rupture strength.*

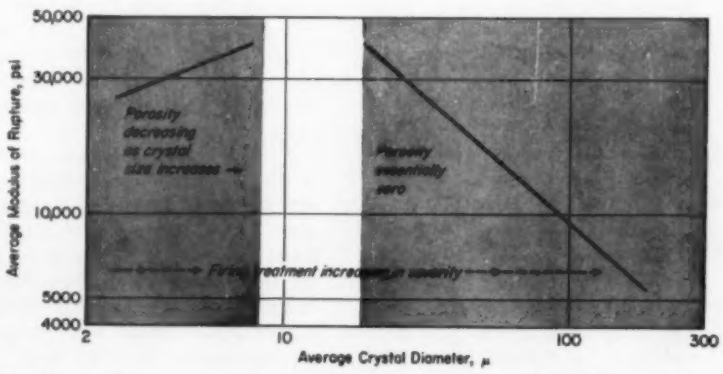


Fig 2*—Strength vs crystal size and porosity as affected by firing.*

ductile-type failures, whereas rapid loading (not to be confused with shock loading) increases the stress required for fracture.

The effect of strain rate on fracture strength is believed to be associated with the energy transfer process involved in fracture. Elastic energy in the material is transferred to free surface energy when the fracture develops or propagates. A finite time is required to achieve the energy equilibrium brought about by fracture. When the rate of loading is increased, the shorter time available to achieve this equilibrium at a given stress level permits greater loads to be withstood.

Distribution of values — Any comparison of the relative fracture strengths of different ceramic materials should not be made on the basis of mean strength values alone. The scatter of individual strength values in each material should also be considered. (See box on p 83).

Getting optimum material quality

In specifying and designing with ceramic materials, the designer or engineer should usually work with the materials supplier more closely than is necessary in the case of many other more standardized engineering materials. A number of processing steps can be taken to obtain the maximum in desirable properties of any given material. These steps usually have to do with inclusions, grain size or other features of the ceramic's internal structure which have a critical effect on fracture strength.

Inclusions — Pores or other scatter inclusions act as notches in lowering the stress required to cause fracture of ceramics. Fig 1 shows the effect of porosity on fracture strength of two ceramic materials.

A convenient method of lowering porosity is to fire at a higher temperature, or for a longer period of time. However, higher temperatures or longer firing times also favor crystal growth in the material, which results in decreased strength. Fig 2 shows the effect on fracture strength of decreasing porosity and increasing grain size resulting from increased severity of firing treatment. The effect of decreasing porosity at first offsets increasing grain size, and strength of the material increases. After porosity is reduced to essentially zero, grain growth continues and strength decreases. Thus, a compromise must be reached and a material selected with both porosity and grain size minimized.

Increasing purity of the ceramic may also provide some strength improvements, though this is unproved. There seems to be no conclusive evidence that minor impurities in a ceramic have an appreciable effect on strength. However, the generally accepted theory of the mechanisms of fracture and flow suggests that impurities in the structure would lower fracture strength and raise yield strength.

Other causes of failure—In a nominally sound, low porosity ceramic, the critical defects which cause fracture are not well-known, and no doubt differ with the material. Possible defects include atomistic-scale imperfections, phase boundaries, surface scratches, and various sorts of localized internal stresses caused by differential or directional thermal expansions or elasticities of phases present.

The locations of defects can also have an important effect on fracture strength, i.e., whether defects are located on surfaces or interiors of bodies. For example, in glass and porcelain, surface defects are critical in initiating fracture. Tempered glass can be produced only because of the critical nature of surface flaws. If internal flaws were critical, tempering would weaken glass. In other cases, internal defects are more critical than surface defects. Generalities cannot be drawn as to the strength characteristics that may differ between surface and volume-sensitive materials. It seems plausible that a material might be surface-sensitive in one situation and volume-sensitive in another.

How Materials Fail

When stressed, a material can fail in either of two distinctly different manners: by ductile or by brittle behavior. Ductile failure is excessive plastic flow or yielding, and results from a shear component of the stresses applied. Brittle failure is separation or fracturing without plastic flow and results from tensile stresses within the material.

Whether a material will fail in a ductile or brittle manner depends in part on the ratio of shear-to-tensile stresses acting, and in part on the strength characteristics of the material. A material with a high ratio of fracture-to-yield strength will fail in a ductile manner when stressed beyond its yield point. Materials such as ceramics have no detectable yield point, and thus almost always fail in a brittle manner.

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Where to Use Urethane Foams

by **T. P. Dougan,** *Executive Vice President, American Latex Products Corp.*

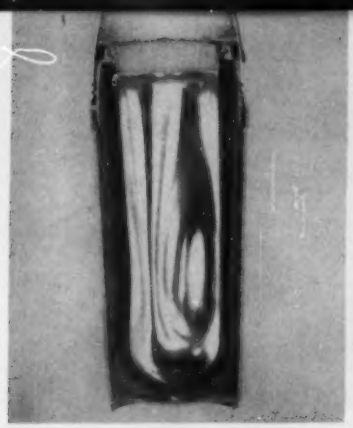
1. ***Rigid*** *foams are used for thermal insulation, high strength-to-weight ratio, electrical insulation, and buoyancy.*

Target drone XQ-10, produced by Radioplane of Van Nuys, is made of reinforced plastic skin with rigid foam core. Only metal part is aluminum wing beam. A 10-lb per cu ft foam is used in leading edge of wing for optimum strength and resistance to impact. Densities are varied in other components to get best compromise between weight and durability required to withstand rough landings.

Piggy-back luggage containers, contoured to fit belly cargo compartments of Douglas DC-7's and DC-8's, are ½-in. thick reinforced plastic-rigid foam sandwich construction. Weighing only 84 lb, containers take 8000-lb load with a deflection of less than 3/16 in.

Containers are loaded with luggage at check-in counters. By mechanized handling they are sent to plane where fork truck hoists them through cargo hatch to rest on rollers on parallel racks within the plane (capacity: 12 units in DC-7, 14 in DC-8). After flight, containers are removed and brought to luggage counters for unloading before passengers arrive.

Other similar uses . . . Recently developed one-man "flying platform" has rigid foam-filled, 48-in. dia lower ring section for light weight plus structural strength . . . Skinless rocket fins consist of rigid urethane foamed in mold around small metal attach-plate . . . Highly sensitive wind vane formed by foaming 2.5-lb per cu ft foam around small bearing on end of aluminum rod. Needs no finishing, resists weather, is highly sensitive to wind direction . . . Large display models of commercial aircraft produced economically and rapidly by foaming in one piece in mold.



Thermos bottle is one of many uses of rigid foam as thermal insulation. Low k factor of 0.19 plus ability to absorb energy make well-insulated, break-resistant bottle.

Other similar uses . . . Insulation of small refrigerator cabinets, refrigerator doors or coils. Inexpensive production is additional benefit, e.g., economical plywood molds can be used for encapsulating coils . . . Aircraft rocket launcher doors . . . Encapsulation of valves for hot or cold liquids and controlled temperature devices.

Potted transformers and electronic plugs typify dielectric uses for rigid foam. Penetration by foam of all areas to be potted is assured by both capillary action of resin and pressure generated by foaming. Resin adheres strongly to all surfaces. Other benefits include: 1) light weight, 2) protection from both external vibration and vibration caused by inductive hum, and 3) protection from moisture and heat.

Aircraft radomes make use of "transparency" of foams to waves of radar frequency. Reinforced plastic-urethane sandwich construction used in these radomes for Lockheed's F-94C Starfire, is strong, lightweight and easily fabricated. Radomes protect antennas from airstream, dust and moisture. Similar construction is used in radomes for radar picket planes and commercial aircraft.

Plywood cabin cruiser is made virtually unsinkable by using 200 lb of 2-lb per cu ft foam to provide buoyancy for an additional 5000 lb of weight. Rigid urethane is foamed-in-place in fuel compartment abaft the engines, and under the chain locker and forward cabin bunks of this experimental 30-ft cruiser by Jeffries Boats.

At right, urethane is shown foaming up around exhaust pipes and two gas tanks, supported prior to foaming only by cradles. In addition to buoyancy, foam provides: 1) hull rigidity, 2) thermal insulation for exhaust pipes, 3) corrosion protection for pipes and tanks, and 4) simplified construction by eliminating several structural members. Also, if hull is pierced, closed-cell foam keeps out water; if gas tanks rupture, foam acts as barrier to gas and vapor.

Other similar uses . . . Large naval mooring buoys of rigid foam used in Alaskan waters. Foam maintains buoyancy even when damaged by ice or sharp-shooting, target-practising Eskimos . . . Floats for valves handling corrosive fluids . . . Efficient repair material for damaged aquatic sports equipment. Voids and other damaged areas can be quickly filled by foaming urethane in the area, sanding down and finishing.

2. **Semi-rigid** *foams are used for thermal or acoustical insulation or energy absorption.*

Official U.S. Navy Photo

Navy Dept.

Nuclear sub Grayback uses about 750 lb of semi-rigid foam to replace glass wool insulation in refrigerated compartments. Shown at right is inside of chill room prior to insulating with foam. Foam is mixed in portable gun and fed through holes shown in aluminum sheathing.

Evaluation by the Navy showed following benefits of foam over glass wool: 1) High efficiency of insulation is retained because breather holes previously required to compensate for pressure change are no longer needed. Holes permitted seepage of air and moisture into insulation reducing its efficiency. 2) Foam seals any open seams, eliminating soldering and welding previously required for airtightness. 3) Maintenance costs reduced by elimination of periodic replacement of insulation due to packing of glass wool. 4) Improved efficiency of insulation permits reduction in either size of compressor or thickness of insulation. 5) Strength and energy absorption of foam makes lightweight sheathing more durable. 6) If insulation sheathing is damaged, no danger from airborne glass wool particles.

Cold annealing tank used to anneal metals in liquid nitrogen is made of steel, insulated with 2-lb per cu ft foam. Semi-rigid foam provides resilience necessary to compensate for dimensional changes in tank with change in temperature.

Used by both Douglas and Northrop, the 12 x 5 x 5-ft tanks use 300 lb of 1-ft thick foam, and can be fabricated in 45 min. Previous tanks, insulated with cork, required 8 hr to fabricate. At 70 F cork has a k factor of 0.30; urethane's k factor is 0.19 at 70 F and decreases with decreasing temperature.

Other similar uses . . . Sprayed coatings of foam used for thermal and acoustical insulation. Maximum thickness of initial coating about 1 in. Subsequent coats can be built up to any final thickness.

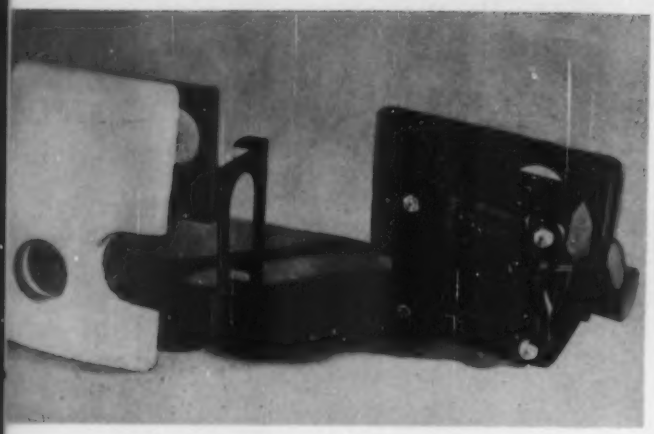
Frangible nose cone, made of reinforced plastic and 3-lb-per-cu-ft semi-rigid foam, cushions recoverable target drone during parachute landing, thus protects delicate instrumentation. Used on RP-70 drone produced by Radioplane of Van Nuys, the 10-in. foam nose reduces landing impact by about 10 g's by progressively collapsing instead of bursting. After landing (right), collapsed cone can be quickly replaced and drone is operational again within 1 hr.

3. ***Flexible*** *foams are used for seat cushioning and other energy absorption applications, thermal and acoustical insulation, and novelty items.*

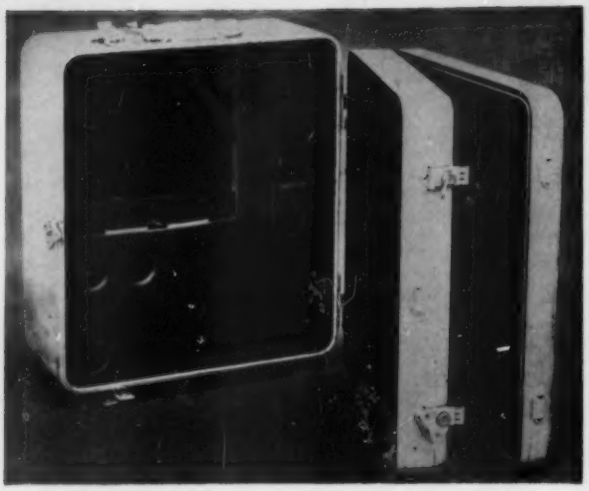
Seat cushions, such as these aircraft cushions produced by Teco Aircraft, are lighter than foam rubber, and resist food and drink stains and flame. "Feel" of the seat cushion can be altered by changing density or composition of foam. Most urethane cushions are of polyether type. Of particular benefit in car seats: urethane cushions do not tend to collapse sideways when turning corners.

Other similar uses . . . Auto crash pads for dashboards and sun visors . . . Beach and pool furniture such as pads for chaise lounges, boat bunks and sunbathing. Pads resist abrasion, weathering, chlorine and salt water . . . Variety of home items such as rug underlays, and pads for cribs, bassinettes and bathinettes, are non-skid because of open-cell structure and can be washed in machine and hung to dry. Foam resists urine, milk, soap and detergents . . . Hospitals use foam, which can be steam sterilized, for movable floor pads for crippled patients, resilient bandages and under-skin surgical inserts . . . Animal bandages and saddle pads . . . Sponges where resistance to abrasion, chemicals, acids and solvents is critical . . . Non-slip insulating pads for phonograph turntables are relatively static-free, reduce rumble and hum of low priced sets . . . As lining for clothes, flexible foam is comfortable and good thermal insulator . . . Novelty items of all sorts made of flexible foam, e.g., marine life replicas ranging from sharks and starfish to sea anemones are molded for Pacific Ocean Park's "Neptune's Kingdom." Electric motors provide realistic motion.

See also photos on next page →



Camera pad at left fits camera bracket (right) to dampen vibration. Camera is designed for use in supersonic aircraft. Flexible foam used here is special high density, filled composition.



Instrument case of low hysteresis polyether-type foam protects instruments against vibration and shock. Other benefits: 1) good thermal insulation, and 2) inertness of foam precludes corrosion or discoloration of highly polished surfaces. In other applications, foam can be molded to shape of instrument.

Ear pads provide good acoustical insulation by damping high frequency jet engine noise. Worn by Lockheed workers, pads are made of polyester foam formulated for "slow memory." Such foams provide little reciprocal pressure, providing maximum comfort.

Urethane Foams: What They Are and How Much They Cost

Urethanes, by definition, are reaction products of an isocyanate and a polyol. Urethane foams are those urethanes formulated to generate gases during the reaction to form a cellular structure. Most urethane foams are reaction products of a diisocyanate and a polyester or a polyether resin.

Whether rigid, semi-rigid or flexible, urethane foams have in common: 1) inertness to a wide variety of chemicals, 2) resistance to sunlight and weathering, 3) good aging characteristics, and 4) ability to be foamed in place to fill virtually any shaped cavity. Fire resistant formulations are also available. Typical property ranges obtainable are shown in the table. Foams are extremely versatile in that wide variations in specific properties can be obtained by altering basic constituents or by altering formulations.

TYPICAL PROPERTIES OF URETHANE FOAMS

Type➡	Rigid	Semi-Rigid
Nominal Density, lb/cu ft➡	2-22	1.5-18
MECHANICAL PROPERTIES		
Compr Str, psi		
Ultimate	90-1570	—
50% Defl	—	9-530
Yield	—	4-300
Compr Mod, psi	4000-36,000	170-8000
Ten Str, psi	80-1070	18-300
Ten Mod, psi	600-13,000	325-12,000
Shear Str, psi	80-610	7-175
Flex Str, psi	140-> 1800	10-650
Rec from 50% Compr Def, %	—	58-90
PHYSICAL PROPERTIES		
Coef of Ther Cond[a] Btu/hr/sq ft/°F/in.	0.19-0.34	0.19-0.29
Coef of Acoustical Absorption[a]		
250 Cps	—	0.20-0.79
500 Cps	—	0.22-0.99
1000 Cps	—	0.20-0.97
Water Abs (wt incr), %		
25 Days; Total Immersion	0.24-2.93[c]	2-24.6
120 Hr; 50% RH	—	0.006-0.084
120 Hr; 98% RH	—	0.36-0.386
ELECTRICAL PROPERTIES		
Dielec Const	1.08-1.36[b]	2.2-2.8
Loss	<0.05-3.1 x 10^{-3}	—

[a] ASTM C384. [b] At 9.375 kmc. [c] 24-hr immersion; all cut surfaces.

Three major types

Rigid foams are mostly polyester types, of closed-cell structure. In addition to their excellent thermal insulating characteristics (see table) they bond tenaciously to surfaces and provide good structural strength. Because of their closed-cell structure, they act as a liquid and vapor barrier.

Semi-rigid foams, usually castor oil-base polyester types, have resilience on the order of 10 to 30%. Resilience is provided by the combination of open and closed-cell structure. The open-cell portion of the foam structure permits gas generated during foaming to escape more easily than in quick-foaming rigid formulations. As a result, less pressure is exerted on cavity walls, making these foams ideally suited for filling large cavities where reinforcement of cavity walls is inconvenient.

Flexible foams have open-cell structure and may be either a polyester or polyether type. The major difference between the two types is in their hysteresis. Polyester foams react to compressive stress in a manner similar to water; the stress is absorbed more by simple resistance than by reciprocal stress. Polyether acts more like foam rubber in that applied stress is met by a reciprocal, spring-like action. Polyester foams can be formulated to provide different degrees of "memory," altering the amount of time necessary for the foam to return to its original shape after stress is removed.

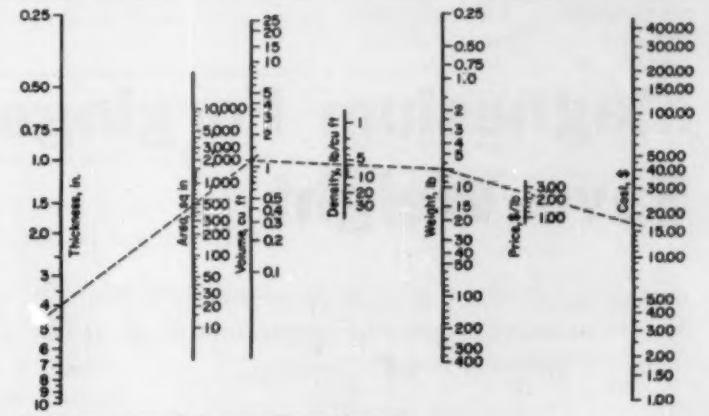
What they cost

The accompanying nomograph can be used to calculate the approximate cost of a foamed-in-place structure. Following is a typical example showing how to use it:

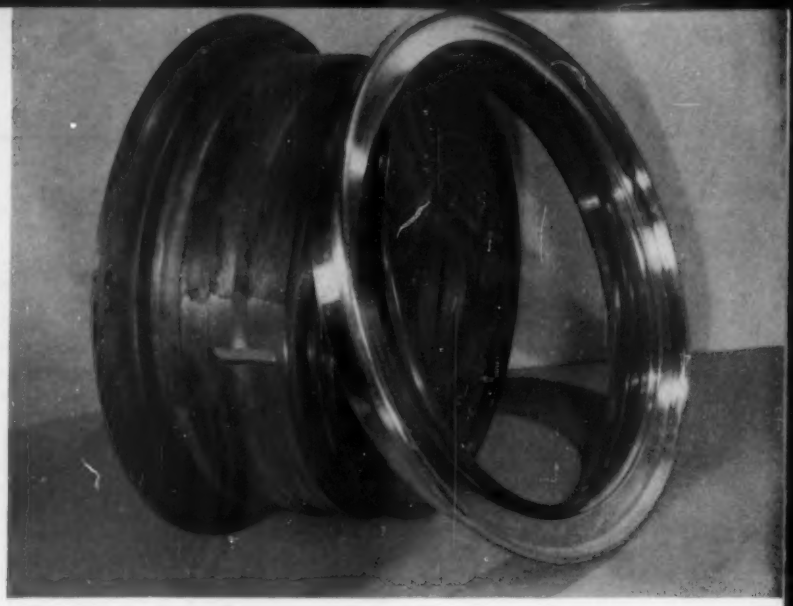
Problem: Determine cost of slab 4 in. thick and 500 sq in. in area. The foam is 6 lb per cu ft in density and priced (for the purpose of this example) at $2.50 per lb.

Solution: Join 4-in. point on thickness scale and 500-sq in. point on area scale with straight-edge and put mark at intersection on volume scale. Join mark on volume scale with 6-lb per cu ft point on density scale and mark intersection on weight scale. Join this point with $2.50 point on price-per-lb scale and read total cost (about $17) on cost scale.

If structure is not a slab, cost can be determined by starting on the volume scale.

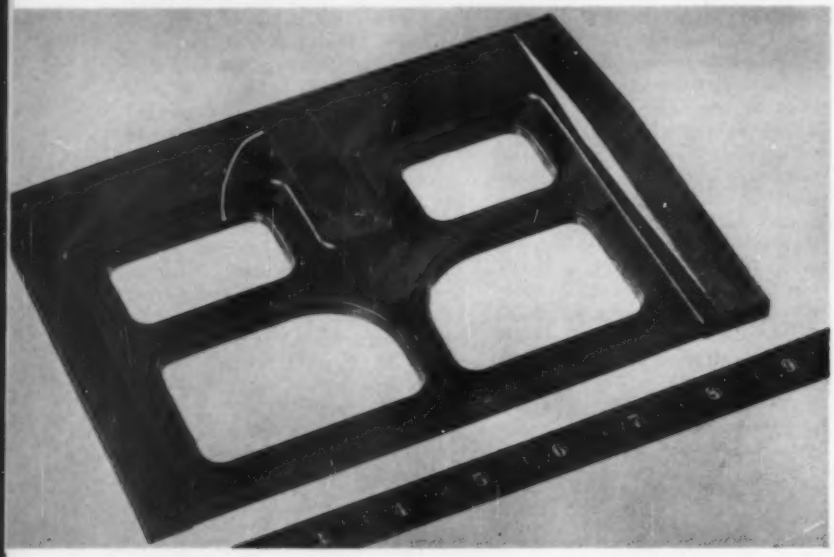


Cost *nomograph for urethane foams.*



Ordnance truck wheel *produced as a low-draft forging from AZ80A-F. Wheel is a 3-piece magnesium forging with 2024 aluminum side ring and steel locking ring. This wheel, weighing 47.4 lb, rolled over 5½ million revolutions before failure; a standard steel wheel, weighing 93.4 lb, failed after 3 million revolutions.*

Control surface *of air-to-air missile produced as a no-draft forging from ZK60A-T5 by Bergman Mfg. Co. weighs only 7½ oz.*



Magnesium Forgings Save Weight

A growing need for good stiffness-weight ratios has led to increasing use of magnesium forgings in airborne equipment and structures.

by **Lester E. Wilensky,*** *Dow Chemical Co.*

■ Use of magnesium forgings has increased greatly during the past few years. At the height of the Korean war, during 1952, only 25,000 lb were used; by 1956, annual consumption had reached nearly a million pounds. This growth has resulted chiefly from the aircraft industry's need for lighter, stronger structural components. Magnesium forgings offer chiefly good fatigue strength and a high stiffness-weight ratio. In addition, of course, they offer the outstanding machinability of magnesium and the metallurgical soundness and good finish characteristic of forgings.

Properties depend mainly on working

The properties of most commercial magnesium forging alloys (Table 1) depend primarily upon the amount of working during the forging operation. No solution heat treatment is used (a recent exception is discussed later), although slight benefits may result from a low temperature aging cycle. Aging ZK60A forgings 24

* This article was prepared by the author shortly before his death in an airplane accident in April, 1958.

TABLE 1—MECHANICAL PROPERTIES OF MAGNESIUM FORGINGS

Alloy and Temper ➡	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation, %	Compr Yield Strength, 1000 psi	Bearing Strength, 1000 psi	Shear Strength, 1000 psi	Brinell Hardness
M1A-F	36	23	7	16	56	18	47
AZ31B-F	38	28	9	16	70	19	55
AZ61A-F	43	26	12	17	72	20	55
AZ80A-F	46	31	8	25	68	22	69
AZ80A-T5	50	34	6	28	80	23	72
ZK60A-F	46	32	15	26	80	—	—
ZK60A-T5	47	33	13	28	85	23	72

hr at 300 F and AZ80A forgings 24 hr at 350 F produces the -T5 temper.

High strength magnesium forgings are usually made on a hydraulic press rather than a hammer. (Some magnesium alloys, such as AZ80A, cannot accommodate the rapid crystal distortion that occurs in hammer forging.) The slower-acting press exerts uniform pressure throughout its stroke and can be made to dwell at its completion.

Since the amount of reduction and the forging temperature (not heat treatment) govern the level of properties in magnesium forgings, it is desirable to work, or reduce, the metal as much as possible. Much depends upon selecting the proper forging procedure—not an easy task for complex forgings having varied section thicknesses. Large forgings produced from cast stock require much working in the press to attain maximum properties.

One way to obtain maximum strength in a magnesium forging is to start with forging stock pre-extruded to some preliminary configuration. Where applicable, such pre-shaped blanks lead not only to stronger forgings but also to cheaper and quicker processing. The good properties gained from working during extrusion are preserved, and forging operations are minimized, saving labor and die costs.

This approach is somewhat restricted since some part configurations forbid it. Where pre-extruded blanks are not possible, however, it may still be possible to modify the forging method to produce an equivalent amount of work in the forging press.

One alloy can be strengthened by heat treatment

Some of the forging restrictions outlined above may be eliminated by the recent development of a heat treatment for ZK60A. It is now possible to solution heat treat, quench and age ZK60A forgings to the -T6 temper. This development gives a wider latitude not only in the design of complex magnesium forgings with heavy sections but also in the actual forging operations.

TABLE 2—EFFECT OF TEMPER ON MECHANICAL PROPERTIES OF ZK60A

Temper ➡	-F	-T5	-T6
Ten Str, 1000 psi	38-46	40-47	44-53
Yld Str, 1000 psi	16-33	18-35	22-46
Elong, %	10-20	9-17	6-13
Compr Yld Str, 1000 psi	14-28	18-29	20-32

Table 2 compares mechanical properties of ZK60A alloy in the conventional -T5 temper, the -F temper, and the new -T6 temper. The -T6 properties were obtained by solution heat treating 2 hr at 930 F in a protective atmosphere, quenching in hot water, and aging 24 hr at 300 F. The most significant increase in properties is in the tensile yield strength; the -T6 temper gives the designer a more favorable ratio of tensile yield to ultimate strength. Similar improvement in compressive yield strength is prevented by the increase in grain size resulting from exposure to the solution heat treatment cycle. An extra benefit from the -T6 treatment is the improvement in short time tensile properties. ZK60A-T6 forgings have the same properties at 400 F as conventional ZK60A-T5 forgings at 300 F. Fatigue test results for ZK60A-T6 compare favorably with similar data for ZK60A-T5.

Because the properties of ZK-60A-T6 are established as a result of heat treatment, forge shop restrictions can be relaxed. Restriking to salvage out-of-toler-

Select magnesium forgings if . . .

1. Stiffness, strength in bending or local instability are factors in the design.
2. Fatigue strength, rather than static strength, is most important.
3. Dimensions of details, such as bosses, lugs and flanges, are more important than strength.
4. Minimum forgeable section does not permit full utilization of the strength of other metals.
5. Damping capacity may be important.
6. Good elevated temperature strength is required.
7. Pressure tightness and light weight are required.
8. Significant amounts of machining are required.

ance forgings can be permitted, and ZK60A can be forged at higher temperatures to allow filling a more complex die or to reduce the number of dies in a schedule.

Magnesium looks promising for draftless forgings

A new forging development of great interest is the increasing demand for precision draftless forgings, currently used for wheels and for central surfaces of the Falcon air-to-air missile. Although this technique has not yet been generally employed for magnesium, magnesium offers certain advantages:

1. Magnesium's behavior in forging dies minimizes lubrication problems.

2. Magnesium requires no greater pressure than aluminum and, in some cases, considerably less.

3. With the exception of ZK-60A-T6, discussed above, properties of conventional magnesium forging alloys stem from working rather than heat treatment. In general, therefore, magnesium is not subject to the warpage usually associated with quenching.

Three design suggestions for magnesium forgings

1. Specify strength where needed. Identify those areas within the part where strength requirements are critical. Specifications for magnesium forgings given in Fed Spec QQ-M-40a are guaranteed minimum mechanical properties for bars taken from the direction of maximum grain flow. Informed of your needs in advance, however, the forging supplier may be able to produce forgings with desired properties in other directions. Mechanical properties of bars taken from various directions in magnesium forgings are compared in Table 3.

2. Consider heat requirements. How much heat must the part withstand, and for how long? Temperature resistance depends not only upon the alloy selected, but also upon the relative bulk of the part. Magnesium's high specific heat and high conductivity make the bulk factor especially pertinent; for brief exposures, magnesium becomes heat-saturated much less quickly than competing metals. Magnesium alloys developed specifically for elevated temperature service have been widely publicized; casting alloys have been available for some time; and recently extrusion and sheet alloys with better elevated temperature characteristics have been used in several new aircraft and missile designs. New forging alloys expected to be announced this year will permit utilization of forged magnesium at temperatures up to 900 F. Applications are developing in the substructure of missiles, including such parts as internal stiffening members, fins and control surfaces, bulkheads and firewalls.

3. Use generous fillets and radii. Careful design will reduce notch effects and permit adequate metal flow.

Larger forging billets are available

Magnesium forging stock is supplied as cast ingot or pre-extruded billet. Ingots are cast by a direct chill, continuous cast process and are commercially available in large diameters up to a nominal 16 in. New facilities should soon make much larger diameters available. Until recently, pre-extruded stock has been limited to standard diameters of less than 10 in., but this maximum size has been doubled with the availability of larger equipment. Thus, fine-grained billets are now available in large diameters.

Best uses are airborne

Magnesium forgings have found and will continue to find their best markets in airborne equipment and structures, specifically where design requirements call for good stiffness-weight ratio or fatigue strength.

Best known examples are forged aircraft wheels. Other forgings made of magnesium include aircraft brake housings and fuel meter bodies.

In the Sikorsky helicopters, magnesium was selected to meet certain stiffness requirements in the hub plate forgings that support and transmit rotation to the rotor blades. Use of magnesium instead of aluminum saved almost one-third of the weight, since the stiffness-weight ratio controls the design. The latest and largest Sikorsky helicopter uses 1144 lb of forged magnesium in various parts—nearly 10% of the total structural weight—compared with 273 lb of magnesium forgings in an earlier model.

TABLE 3—DIRECTIONAL PROPERTIES OF SEVERAL MAGNESIUM FORGINGS

Alloy and Temper	Direction	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elong, %	Compressive Yield Strength, 1000 psi
AZ61A-F	Long.	44	28	14	19
	Trans.	38	19	13	15
AZ80A-T5	Long.	50	35	8	28
	Trans.	45	29	8	24
ZK60A-T5	Long.	49	38	14	28
	Trans.	43	26	16	26

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Materials
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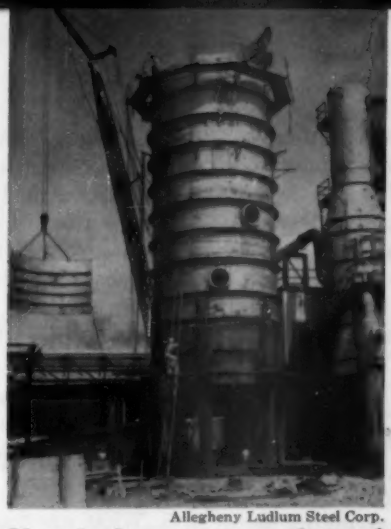
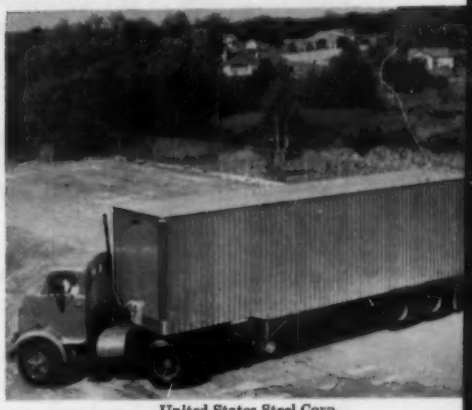
January 1959

STAINLESS STEELS ARE USED IN . . .



Allegheny Ludlum Steel Corp.
Chemical process equipment



United States Steel Corp.
Transportation equipment

Allegheny Ludlum Steel Corp.
Food handling equipment

Electro Metallurgical Corp.
Consumer applications

How to Select a Stainless Steel

by John L. Everhart,
Technical Editor,
Materials in Design Engineering

No single grade of wrought stainless is satisfactory for service under all conditions. Choosing the correct grade for a specific application is a matter of choosing the best possible combination of:

- *Corrosion or heat resistance*
- *Mechanical and physical properties*
- *Ease of fabrication*
- *Availability*
- *Price*

■ Many years ago, it was discovered that chromium increased the corrosion resistance of iron-base alloys. From this discovery has developed a large family of steels which are loosely termed "stainless steels," though the designation is not strictly accurate. In addition to chromium, which must be present in amounts above 11.5% to confer "stainless" properties, these steels contain carbon, manganese and silicon. They may also contain such additional elements as nickel, molybdenum or columbium.

More than 30 wrought grades of stainless are designated as standard by the American Iron and Steel Institute (AISI), and about as many cast grades are designated as standard by the Alloy Casting Institute (ACI). In addition there are many proprietary grades and over 20 non-proprietary grades not listed by the AISI.

The three basic types are 12% chromium, 17% chromium and 18 chromium-8% nickel. These serve for most uses, but problems of formability, attainable hardness or weldability have required modifications and refinements of the basic steels. In addition, steels of higher chromium content have been developed to meet service conditions too severe for the basic grades.

This manual aims at helping the engineer select a suitable grade for his application. Because of space limitations, it is limited to the wrought steels, although much of the information applies equally to the cast grades.

The approach taken in this manual is to discuss in turn the five important questions that should be considered by any potential user of stainless steel:

1. What corrosion or heat resistance is required?
2. What mechanical and physical properties are required?
3. How is the part to be fabricated?
4. What forms and sizes will be required?
5. What are the cost factors?

Notice that resistance to the environment is the basic consideration in selecting stainless steels. The other four factors narrow the list of acceptable grades for a particular use, but it is often necessary to make compromises among the factors to obtain the optimum grade. Consultation with a producer of stainless steel is advisable before final selection is made.

Before proceeding to these five questions, the engineer who is not fairly familiar with stainless steels is advised to read the section on "The Three Types of Stainless" which appears in a box on the opposite page.

1. What corrosion or heat resistance is required?

Since there are so many factors involved in corrosion, selection of a suitable grade of stainless steel cannot be made on a handbook basis. Consultation with a producer of the steel is essential. Unless the problem involves a common corrodent, however, the proper grade must be determined by tests under service conditions.

The first consideration is the degree of corrosion that can be tolerated. If good appearance and freedom from discoloration are necessary, or if the product being handled must not be contaminated, the steel selected must be practically immune from attack. However, if a predictable rate of attack is permissible, selection can be made from a wider variety of grades.

The stainless steels owe their corrosion resistance to the formation of a surface oxide film. Therefore, strongly oxidizing conditions promote corrosion resistance. Conversely, reducing conditions, particularly if maintained for long periods, deprive the steel of the oxide film and lead to attack of the metal. The most important types of corrosion that can be encountered with stainless steels —general corrosion, intergranular corrosion, galvanic corrosion, pitting, and atmospheric corrosion (including scaling)—are discussed below.

General corrosion

Austenitic steels—In the austenitic group, all of the 18-8 types except 316 and 317 show equally good resistance to corrosion; in most environments the 200 series have comparable properties. Types 309 and 310 resist the same solutions as the 18-8 types but their higher alloy content enables them to withstand higher concentrations and temperatures. The molybdenum-bearing 18-8 types are the most resistant to corrosion of the standard stainless steels because of their resistance to pitting.

At room temperature, austenitic steels are highly resistant to strong oxidizing acids such as nitric. Resistance to more dilute acids varies; in most acids, if an oxidizing agent is present it will generally prevent attack. Sulfuric acid may or may not attack these steels, depending on concentration, temperature and the presence of an oxidizer. Cold concentrated sulfuric does not attack the austenitic grades; hot concentrated sulfuric does. Because molybdenum increases the resistance of 18-8, type 316 is used in handling some concentrations of sulfuric acid that cannot be handled by the molybdenum-free alloys. A proprietary austenitic alloy containing both molybdenum and copper, Carpenter 20, has been developed

for handling sulfuric acid.

The stainless steels, including type 316, are not recommended for handling hydrochloric acid, the other halide acids and acid halide salts. These chemicals have a tendency to destroy the surface passivity and reduce corrosion resistance.

Organic acids can generally be handled by types 304, 316, 317 and 347; with hot concentrated solutions the molybdenum-bearing grades are definitely superior.

The austenitic grades are generally resistant to the alkalis, and to solutions of organic and inorganic salts with the exception of the halides.

Ferritic steels—Of the ferritic grades, type 430 can be used almost interchangeably with the austenitic 18-8 types in many applications, particularly under strongly oxidizing conditions. Generally speaking, however, the ferritic grades are restricted to a narrower range of corrosive conditions than the austenitic grades.

Martensitic steels—The martensitic steels are excellent for service in mild environments, such as the atmosphere, fresh water, steam and weak acids, but are not resistant to severely corrosive solutions. Types 410, 414, 416 and 431 have similar corrosion resistance in both annealed and hardened conditions. Of this group, type 431 has the maximum resistance of the hardenable grades, and its stainless properties approach those of type 430. Types 420 and the various modifications of 440 must be hardened for maximum corrosion resistance; they should not be used in the annealed condition.

Other factors—In addition to the composition of the metal and the corroding solution, other factors influence corrosion. These include impurities, temperature of the corrodent, and aeration.

Pure chemicals or solutions are seldom used commercially and the presence of impurities must be carefully considered. Some impurities inhibit the corrosive action of a solution, others accelerate the action. For this reason, published tables, usually based on laboratory data obtained on pure chemicals, are of value only as a method of screening to eliminate obviously unsuitable stainless grades.

Temperature is a very important factor, since activity increases with temperature. A stainless type that is satisfactory for handling a cold solution may be unsuitable for handling the same solution at an elevated temperature.

The degree of aeration is important also. Stainless steel in a liquid exposed to the air, or through which air circulates, can have greatly improved resistance to corrosive effects than in the

The Three Types of Stainless

The stainless steels can be divided into three groups, based on their structures: 1) austenitic, 2) ferritic, and 3) martensitic. The general characteristics of these groups are summarized below. Some characteristics of the individual grades are given in Table 1 on the next page.

In addition to the standard grades, there are proprietary grades which have been developed for specific applications. These include hardenable alloys developed for improved corrosion resistance, and alloys developed for greater resistance to scaling. Some of these alloys will be discussed briefly in the text. Further details can be obtained in MATERIALS & METHODS Manuals No. 109 and 126.

1. Austenitic grades

These are the chromium-nickel and chromium-nickel-manganese grades. They can be hardened only by cold working; heat treatment serves only to soften them. They are nonmagnetic in the annealed condition, although some may become slightly magnetic after cold working.

The basic composition, type 302, is widely known as 18-8 and is the general purpose austenitic grade. There are 22 modifications based on this grade (including the chromium-nickel-manganese 200 series). In these varieties, 1) the chromium-nickel ratio has been modified to change the forming characteristics, 2) the carbon content has been decreased to prevent intergranular corrosion, 3) columbium or titanium has been added to stabilize the structure, or 4) molybdenum has been added, or the chromium and nickel contents have been increased, to improve corrosion or oxidation resistance.

2. Ferritic grades

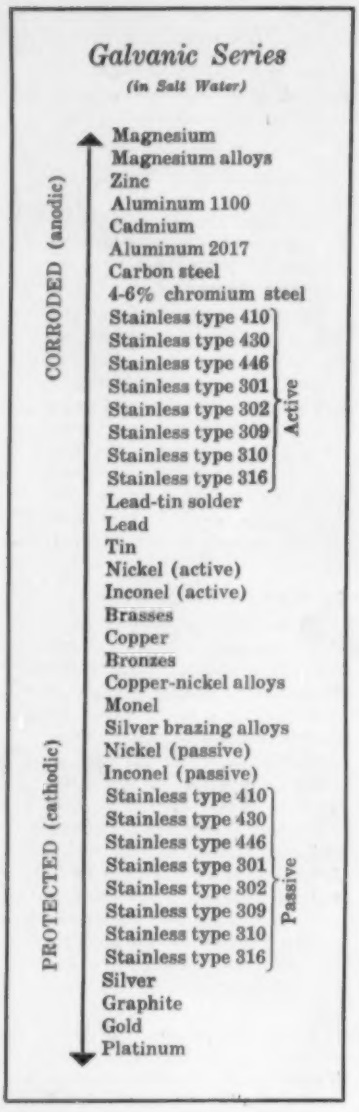
These stainless grades contain chromium but no nickel. They can be hardened to some extent by cold working but not by heat treatment. They are always magnetic.

The base composition is type 430, nominally 17% chromium. In this series, there are two free-machining modifications and two grades with increased chromium to improve scaling resistance. Also included in the ferritic grades is a 12% chromium steel (basic composition of the martensitic grades) that contains aluminum to prevent hardening.

3. Martensitic grades

These stainless grades contain chromium and, with two exceptions, no nickel. They differ from the preceding groups in that they can be hardened by heat treatment. They are always magnetic.

Base composition in this series is type 410, nominally 12% chromium. There are ten standard compositions in this series. Several of the grades are modified to improve machinability, and others have small additions of nickel to improve the mechanical properties. Still others have greatly increased carbon content; 440A, B and C have carbon content in the tool steel range and are hardenable to the highest levels of all the stainless steels. Unlike all of the lower carbon grades (except type 420), these steels develop maximum corrosion resistance only in the fully hard condition.



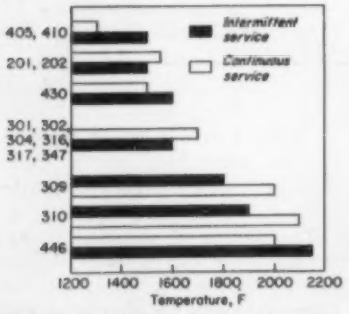


***Fig 1**—Maximum service temperatures for stainless steels; they vary with service conditions.*

same liquid held in a closed container or from which air is excluded.

Intergranular corrosion

This type of corrosion occurs only in the austenitic chromium-nickel grades. If grades 301 or 302, for example, are heated for long periods in, or cooled slowly through, the range 800 to 1450 F, chromium carbides tend to deposit in the grain boundaries, robbing adjacent areas of chromium and making these areas less resistant to attack than the bulk of the metal. Exposure of steels in this condition to corrosive environments can result in intergranular failure. This type of failure often develops adjacent to weldments.

There are two methods of avoiding intergranular attack: 1) the carbides once formed can be redissolved by heating in the range 1800 to 2050 F and quenching, or 2) precipitation can be avoided by using modified grades of stainless. Suitable grades are the extra low carbon grades, 304L and 316L, or the stabilized grades, 347 and 321. The former minimize chromium carbide precipitation; the latter avoid it. All four can be used in the as-welded condition. However, types 347 and 321, which are stabilized with columbium or titanium, should be used for continuous service in the 800 to 1650 F range to resist intergranular attack.

Galvanic corrosion

This type of corrosion occurs when two metals are in contact in a liquid that can carry an electric current, a condition that occurs in practically all aqueous solutions. Under these conditions, an electric current flows through the solution and tends to accelerate the corrosion of one metal and protect the other.

Metals can be listed in their relative order of attack in any solution and such a list, known as the galvanic series, is shown on this page. If any two metals are in contact, the one that is the higher in the series is the one that corrodes.

In this table the stainless steels are listed under "active" and "passive," and their position relative to copper, for example, depends on the environment. Stainless steels are active in the presence of reducing chemicals which prevent the formation of an oxide film; they are passive under oxidizing conditions.

Galvanic attack can be prevented by using metals of the same composition for complete assemblies. If this method is impractical, it may be possible to separate the two metals by an insulating material at the area of contact.

Pitting corrosion

Stainless steels, although apparently unattacked by certain solutions, can fail in these solutions by corroding deeply in certain spots. This phenomenon is called pitting. Although the causes of this type of failure are not fully known, certain factors are known to accelerate the attack. Among these accelerating factors are nicks, dents, rough spots and dirt. If a pit is formed, it becomes a concentration cell (i.e., there is a different concentration of the corrodent in one spot from that in another), current flows and corrosion is accelerated.

In general, this condition is best overcome by selecting a stainless grade that has a higher resistance to the specific solution than the grade in which pitting occurs. The austenitic molybdenum grades, 316 and 317, are less susceptible to pitting than the other grades.

Atmospheric corrosion

Ordinary temperatures — Appearance is a complicating factor in the selection of a stainless grade for atmospheric exposure. In an industrial atmosphere, type 410 and the other 12% chromium grades develop superficial rust after exposure of a few weeks. Although this film acts as a barrier to further attack, it is not attractive. For service in which appearance is not a factor, these grades are satisfactory; type 410 has given satisfactory service for 25 years in roofing. Type 430 resists rust formation but eventually loses its attractive appearance

unless it is cleaned. It is used as automotive trim; cleaning retains the bright appearance. The chromium-nickel grades remain free from these rust deposits indefinitely; types 302 and 304 are used as architectural trim because they remain bright without cleaning.

In coastal atmospheres, the presence of salt in the air results in deposits on the steel surface. Here, types 302 and 304 are satisfactory only if they are kept clean; if cleaning is not practical type 316 or 317 should be used.

Elevated temperatures—Rate of oxidation increases with rising temperature, and differences in resistance to atmospheric attack among the stainless steels become more pronounced as the service temperature is increased. At elevated temperatures, resistance to oxidation is directly proportional to the chromium content, although nickel is also beneficial.

Suitability of a given grade for high temperature use is influenced by type of service. The chromium-nickel steels of the 300 series have relatively high coefficients of expansion. If the service involves cyclical temperature changes of large magnitude, oxidation may be increased by spalling of the protective layer. Therefore these steels can be used at higher temperatures for continuous service than for intermittent service. On the other hand, the chromium steels have lower coefficients of expansion and the oxide layer does not spall; these steels are more suitable for intermittent service than the chromium-nickel types. Maximum operating temperatures for representative steels are shown in Fig 1.

Under oxidizing conditions, sulfur-bearing gases have little corrosive effect on either the chromium or chromium-nickel grades. Under reducing conditions, sulfur greatly accelerates attack on the alloys, particularly those containing nickel. Accelerated attack at high temperatures may also result from the fluxing action of fly ash or oil ash on the stable oxide scale; type 446 is the alloy most resistant to this fluxing action.

2. What mechanical and physical properties are required?

The stainless steels offer a relatively wide range of properties in the annealed or hardened condition. Since tables showing the properties of individual grades are available from the AISI and the steel producers, and in many handbooks, they have not been included in this manual. Instead, differences among the grades will be indicated by comparison of individual properties.

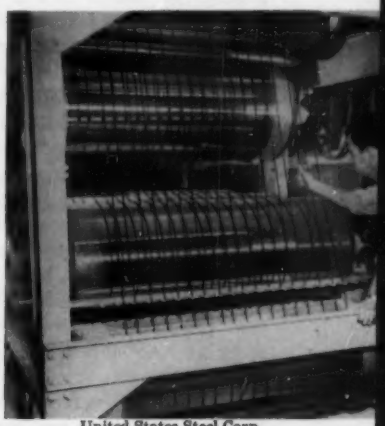
Ordinary temperatures

Tensile and yield strengths of a

Chemical process and other industrial uses include . . .

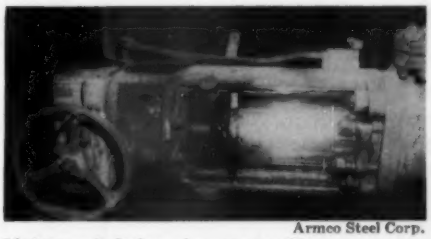
Allegheny Ludlum Steel Corp.

Condenser tubes *for power plants.*



United States Steel Corp.

Drums *for vat dyeing in textile plants.*



Armco Steel Corp.

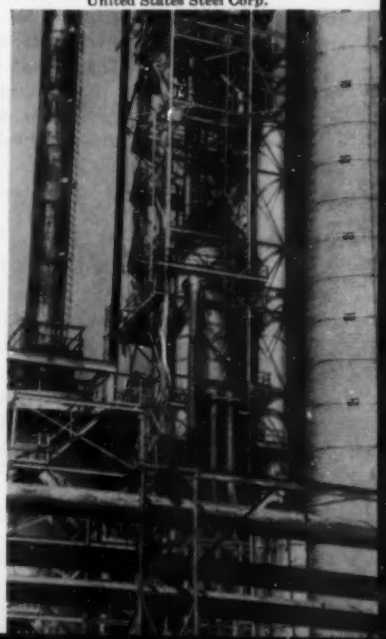
Valve *and fittings in paper mills.*

Lining for reservoir *used to store chemicals.*

United States Steel Corp.

Piping *and reaction vessels in the process industries.*

United States Steel Corp.



number of grades in the annealed condition are given in Fig 2. Tensile strengths range from 65,000 psi for type 410 to 115,000 psi for type 201. Yield strengths range from 35,000 to 55,000 psi. The spread between yield and tensile strength is more significant than the individual values because it is an indication of workability. For example, type 410 with a spread of 30,000 psi is much less readily worked than type 301 with a spread of 70,000 psi.

Ductility, as indicated by elongation, varies significantly with the structure. Austenitic stainless grades have much greater ductility than ferritic or martensitic grades. As shown in Fig 3, elongation is 2½ to 3 times as great in annealed austenitic grades as it is in ferritic and martensitic grades, an indication that the austenitic grades are more readily worked than the others.

Structure is significant also in determining how to increase the strength and hardness of these materials. Neither the austenitic nor the ferritic alloys can be hardened by heat treatment; both can be hardened only by cold working. As shown in Fig 4, the tensile strength of the austenitic grades can be increased to much higher values than are obtainable in the ferritic grades. Data on the effect of cold working on two austenitic grades included in Table 2 show that type 301 work hardens to a much higher degree than type 302.

The martensitic grades can be hardened by conventional quenching and tempering. Table 2 gives the properties of a number of these grades after quenching and tempering at 600 F. Properties, like those of other hardenable steels, will vary with tempering temperature. Type 440C is hardenable to the highest value obtainable in any stainless steel; after tempering at 600 F, this steel has a Rockwell hardness of C57 and a tensile strength of 285,000 psi.

Properties of a number of proprietary stainless steels are also given in Table 2. Some of these grades are martensitic and are hardenable by quenching and tempering; others are essentially austenitic and are precipitation hardenable. These alloys have been included to indicate the range of values obtainable in some of the newer hardenable alloys; additional information can be obtained by consulting the references on p 109.

TABLE 1—CHARACTERISTICS OF

Structure	Hardenability	Magnetic Properties	Group	AISI Type	Nominal Composition, %[a]		
					Cr	Ni	C
Austenitic	Hardenable Only by Cold Working	Nonmagnetic (may become slightly magnetic upon cold working)	Chromium-Nickel-Manganese	201	16-18	3.5-5.5	0.15
				202	17-19	4-6	0.15
			Chromium-Nickel	301	16-18	6-8	0.15
				302	17-19	8-10	0.15
				302B	17-19	8-10	0.15
				303	17-19	8-10	0.15
				303Se	17-19	8-10	0.15
				304	18-20	8-12	0.08
				304L	18-20	8-12	0.03
				305	17-19	10-13	0.12
				308	19-21	10-12	0.08
				309	22-24	12-15	0.20
				309S	22-24	12-15	0.08
				310	24-26	19-22	0.25
				310S	24-26	19-22	0.08
				314	23-26	19-22	0.25
				316	16-18	10-14	0.08
				316L	16-18	10-14	0.03
				317	18-20	11-15	0.08
				321	17-19	9-12	0.08
				347	17-19	9-13	0.08
				348	17-19	9-13	0.08
Ferritic	Somewhat Hardenable by Cold Working	Magnetic	Chromium-Iron	405	11.5-14.5	—	0.08
				430	14-18	—	0.12
				430F	14-18	—	0.12
				430FSe	14-18	—	0.12
				446	23-27	—	0.20
Martensitic	Hardenable by Heat Treatment			403	11.5-13	—	0.15
				410	11.5-13	—	0.15
				414	11.5-13	1.25-2.5	0.15
				416	12-14	—	0.15
				416Se	12-14	—	0.15
				420	12-14	—	0.15[b]
				431	15-17	1.25-2.5	0.20
				440A	16-18	—	0.6-0.75
				440B	16-18	—	0.75-0.95
				440C	16-18	—	0.95-1.2

[a]Single values indicate maximum except as noted. [b]Minimum.

Mn	Si	Other	Purpose
5.5-7.5	1	N 0.25	Low Ni equivalent of type 301
7.5-10		N 0.25	Low Ni equivalent of type 302
2	1	—	High work hardening rate; structural appl; appl req high str and ductility
2	1	—	General purpose austenitic grade
2	2-3	—	Incr Si impr scaling res over type 302
2	1	S 0.15[b], Mo 0.6, Zr 0.6	Free-machining modification of type 302; for heavy cuts
2	1	Se 0.15[b]	Free-machining modification of type 302; for light cuts; also for parts req hot or cold heading
2	1	—	Low-C modification of type 302 to restrict carbide precipitation
2	1	—	Lower-C modification of type 302 for welding applications
2	1	—	Low work hardening rate; spin forming and severe drawing operations
2	1	—	Incr alloy content for impr corr and heat res; welding rod to compensate for alloy loss in welding
2	1	—	High temp str and scaling res
2	1	—	Low-C modification of type 309 for welded constr
2	1.5	—	Elevated temp str and scale res higher than type 309
2	1.5	—	Low-C modification of type 310 for welded constr
2	1.5-3	—	Incr Si impr scaling res over type 310
2	1	Mo 2-3	Mo added to impr corr res; impr creep str over type 302
2	1	Mo 2-3	Low-C modification of type 316 for welded constr
2	1	Mo 3-4	Incr Mo impr corr res over type 316
2	1	Ti 5 x C[b]	Stabilized for weldments subject to severe corr conditions and svc in 800-1600 F range
2	1	Cb-Ta 10 x C[b]	Same as type 321
2	1	Cb-Ta 10 x C[b] but Ta 0.10	Same as type 321
1	1	Al 0.1-0.3	Al added to prevent hardening; for weldments
1	1	—	General purpose, nonhardenable chromium stainless steel
1.25	1	S 0.15[b], Mo 0.6, Zr 0.6	Free-machining modification of type 430; for heavy cuts
1.25	1	Se 0.15[b]	Free machining modification of type 430; for light cuts; also for parts req hot or cold heading
1.5	1	N 0.25	High res to scaling at elevated temp, esp for intermittent svc or sulfurous atm
1	0.5	—	"Turbine quality" grade for steam turbine blades and other highly stressed parts
1	1	—	General purpose, heat treatable stainless steel; for machine parts, pump shafts
1	1	—	Greater hardenability than type 410; for springs, machine parts
1.25	1	S 0.15[b], Mo 0.6, Zr 0.6	Free-machining modification of type 410; for heavy cuts
1.25	1	Se 0.15[b]	Free-machining modification of type 410; for light cuts; also for parts req hot or cold heading
1	1	—	Higher-C modification of type 410; for cutlery, surgical instr, wear res parts
1	1	—	Special purpose hardenable grade; for appl req high mech properties
1	1	Mo 0.75	Hardenable to higher hardness than type 420
1	1	Mo 0.75	Cutlery grade; used also for parts req high hardness and wear res
1	1	Mo 0.75	Highest hardness of hardenable stainless grades; for balls, bearings, races

Properties at ordinary temperatures

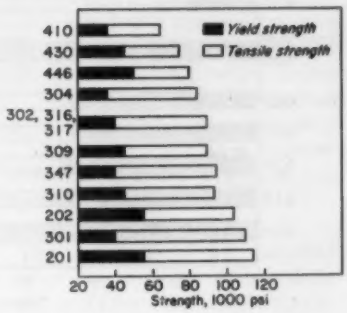


***Fig 2**—Tensile and yield strengths of annealed stainless sheet and strip.*

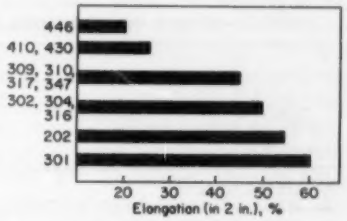


***Fig 3**—Elongation of annealed stainless sheet and strip. Note differences in ductility between chromium and chromium-nickel grades.*

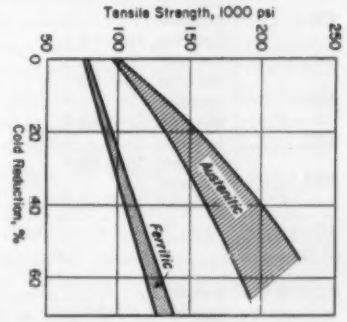


***Fig 4**—Work hardening produces higher strengths in the austenitic than in the ferritic grades.*

Elevated temperatures

Comparisons of the short time, rupture and creep strengths of a number of grades are given in Fig 5, 6 and 7. The austenitic grades are generally stronger than the other grades, particularly at temperatures above 1200 F. Type 316 is the strongest of the austenitic grades and probably the most useful stainless steel for service up to 1200 F; above this temperature it is inferior to types 309 and 310 in resistance to scaling. Recommended maximum serv-

Properties at high temperatures

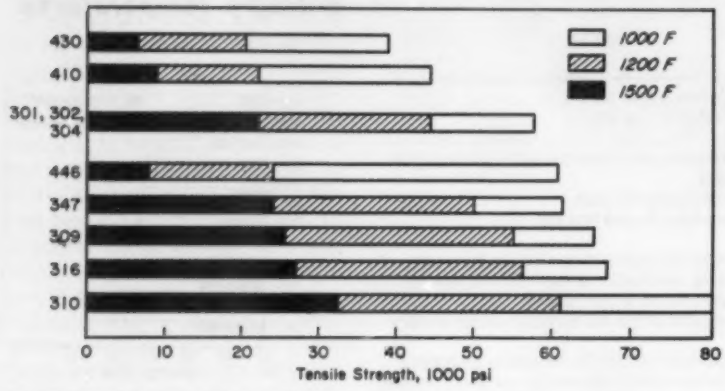


Fig 5—*Tensile strength of stainless steels.*

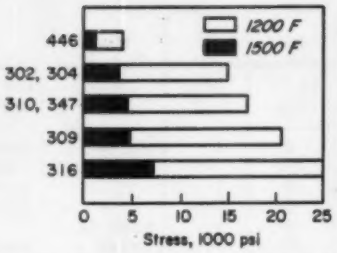


Fig 6—*Rupture strength (1000 hr) of various grades.*

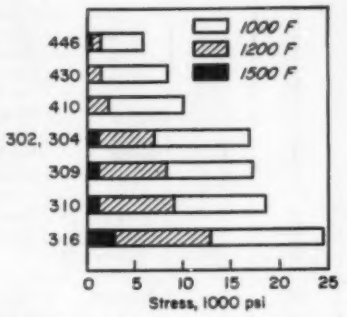


Fig 7—*Creep strength (1% in 10,000 hr) of various grades.*

TABLE 2—EFFECT OF COLD WORK OR HEAT TREATMENT ON SOME STEELS

Grade	Treatment	Yield Strength (0.2% offset), 1000 psi	Tensile Strength, 1000 psi	Elongation (2 in.), %	Rockwell Hardness
AUSTENITIC GRADES					
301	Annealed	33	118	68	B85
	Cold Rolled 45%	200	225	7	C46
302	Annealed	36	94	61	B80
	Cold Rolled 50%	151	177	6	C38
MARTENSITIC GRADES*					
410	Annealed	35	70	30	B82
	Quenched, Temp 600 F	140	180	15	C39
420	Annealed	50	95	25	B92
	Quenched, Temp 600 F	195	230	8	C50
431	Annealed	95	125	20	C24
	Quenched, Temp 600 F	150	195	15	C41
440A	Annealed	60	105	20	B95
	Quenched, Temp 600 F	240	260	5	C51
440B	Annealed	62	107	18	B96
	Quenched, Temp 600 F	270	280	3	C55
440C	Annealed	65	110	14	B97
	Quenched, Temp 600 F	275	285	2	C57
PROPRIETARY GRADES					
Stainless W	Annealed	95	135	7	C25
	Aged ½ Hr at 950 F	195	210	7	C43
17-7 PH	Annealed 1950 F	40	130	35	B85
	Ann. 1750 F; 8 Hr at —100 F; 1 Hr at 950 F	220	235	6	C48
PH 15-7Mo	Annealed 1950 F	55	130	30	B90
	Ann. 1750 F; 8 Hr at —100 F; 1 Hr at 950 F	215	240	6	C48
AM350	Annealed	52	186	22	B94
	Ann. 1710 F; Cooled to —100 F; Temp 950 F	163	189	15	C41
HNM	Annealed at 2100 F; Aged at 1300 F	141	180	16	C36

*Properties after heat treatment vary with tempering temperature. The treatment shown was selected only for purposes of comparison.

ice temperatures (Fig 1) are based on scaling resistance, not strength. For example, type 446 loses strength rapidly and at 2000 F is suitable only for low stress applications. Numerous proprietary stainless grades have been developed for service above 1200 F. Space limitations prevent discussing them in this manual; many of them have been discussed previously in MATERIALS & METHODS Manual No. 104.

Strength is not the only criterion in selecting stainless steels for elevated temperature service. Others are scaling resistance (discussed previously) and stability.

Stability is a problem because most of the chromium and chromium-nickel steels are subject to

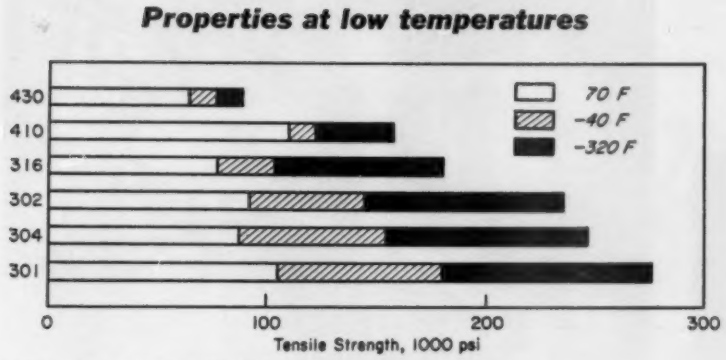


Fig 8—*Tensile strength of annealed stainless steels.*

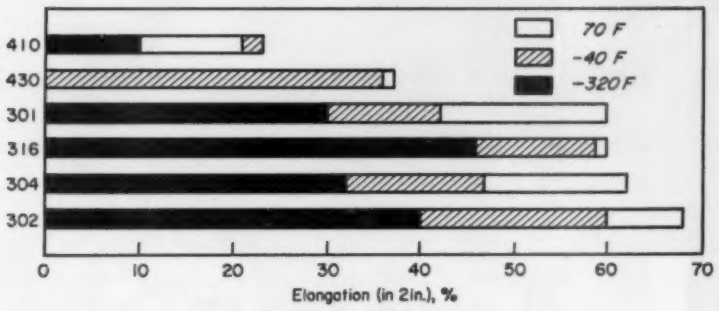


Fig 9—*Elongation of annealed steels.*

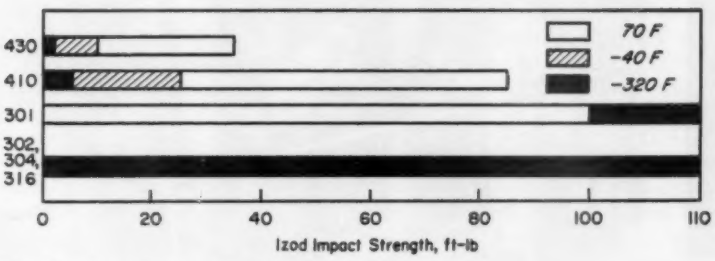


Fig 10—*Impact strength of annealed steels.*

phase changes during prolonged exposure at temperatures in the range 1200 to 1700 F; in addition the chromium steels are subject to embrittlement (known as 475 C embrittlement) upon prolonged exposure near 1000 F. The result is reduction in ductility of the alloys at room temperature, although elevated temperature properties are not impaired. Because of these embrittling effects, the alloys must not be subjected to shock at ordinary temperatures after prolonged exposures in the ranges mentioned. Ductility can be restored by heating above 1700 F and rapid cooling.

In addition to phase changes, the chromium grades have a tendency toward grain growth. This tendency is important only in type 446 because it is the only chromium grade with sufficient oxidation resistance to be used above 1900 F, the temperature at which grain growth becomes excessive. Grain growth cannot be corrected by ordinary heat treatment.

Intergranular precipitation of carbides (mentioned previously) occurs only in the austenitic grades upon exposure to the range 800 to 1450 F. This precipitation makes the steels susceptible to corrosion in certain media. Use of the stabilized grades 321 and 347 is desirable if the steels will be exposed to corrosive media.

Low temperature properties

The strength of all stainless grades increases as temperature is reduced; therefore low temperature strength is not a problem. Typical values are given in Fig 8.

However, ductility varies with the structure (see Fig 9 and 10). Measured by elongation, the austenitic grades retain most of their ductility down to at least –320 F. This retention of ductility is confirmed by impact tests; there is no loss in impact value in these grades as the temperature falls to –320 F. Therefore any of the austenitic grades can be used in low temperature service with excellent results.

Such is not the case with the ferritic and martensitic grades. These grades have transitions from ductile to brittle behavior at moderately low temperatures. Although type 410 shows an increase in elongation between room temperature and –40 F, its impact strength drops markedly over the same range. However, the impact value is still above the minimum of 15 ft-lb set by the American Society of Mechanical Engineers as a criterion for unfired pressure vessel service. On the other hand, type 430, though retaining most of its room temperature elongation at –40 F, fails to meet the minimum requirement of 15 ft-lb impact strength when the temperature drops to –40 F. These figures show that the straight chromium steels have only limited service possibilities at low temperatures.

Physical properties

Several of the physical properties of the stainless steels are

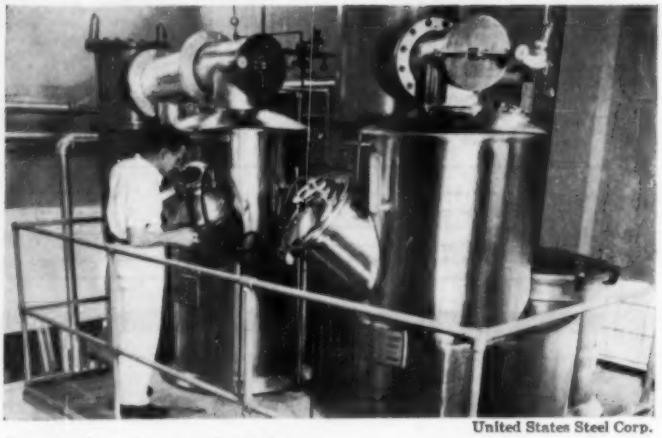
Food and beverage handling applications include . . .

United States Steel Corp.

Cans *for bulk deliveries of milk to restaurants.*

Allegheny Ludlum Steel Corp.

Slides *in meat packing plants.*



United States Steel Corp.

Evaporators *in the dairy industry.*

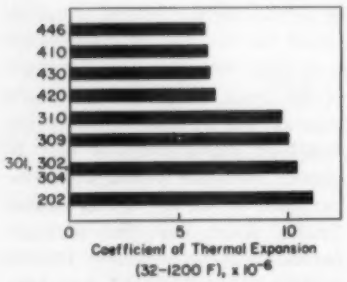


***Fig 11**—Coefficient of thermal expansion of the austenitic grades is roughly twice that of the other grades.*

almost identical regardless of composition. For practical purposes, all of the standard grades have densities of 0.28 lb per cu in., specific heats of 0.12 Btu/lb/°F and tensile moduli of elasticity of 28,500,000 psi.

Electrical resistivity is influenced by structure. In the austenitic grades, resistivity varies from 72 to 78 microhm-cm; in the ferritic grades from 60 to 67; in the martensitic grades from 55 to 60.

There is considerable difference in thermal expansion between the chromium and the chromium-nickel grades, a fact that has been mentioned previously under scaling. As shown in Fig 11, the coefficient of expansion of the chromium-nickel grades is almost double that of the chromium grades.

Transportation applications include . . .

United States Steel Corp.

***Trailer** for handling liquids and bulk cargoes.*

3. How is the part to be fabricated?

In general, all of the wrought stainless steel grades can be fabricated by the methods applicable to carbon steel. However, the relative ease of fabrication depends on composition and, to some extent, on physical condition.

Some of the steels are more readily worked, hot or cold, than others; some have better machinability; some are preferred for applications requiring welding. These are the reasons behind the development of modifications of the basic grades in each category.

Certain generalizations can be made also as a result of structural differences. The austenitic steels are more ductile than the ferritic and martensitic steels. Difference in ductility can be illustrated by the following comparison:

Cr	Ni	C	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong, %
17	—	0.10	60	35	25
17	7	0.10	100	35	60

It is apparent that the addition of nickel has more than doubled the elongation. The austenitic steels are particularly well suited for cold forming operations, but can be readily hot formed and joined.

The ferritic steels are sufficiently ductile and soft to be fabricated by practically all of the standard techniques. They can be hot worked more readily than the martensitic steels; they can also be welded with greater ease, although certain precautions are required.

The martensitic grades can be fabricated with little difficulty if their lower ductilities are taken into account. However, they are not so workable as the austenitic and ferritic grades.

The following paragraphs are intended to point out differences in the working characteristics of the various steels. Space does not permit the discussion of fabricating techniques but there are a number of excellent texts available, some of which are listed among the references at the end of this manual.

Hot working

Although all of the grades can be fabricated to some degree by hot working, some are more suitable than others. Both the 200 and 300 series steels can be hot forged and hot formed readily. They can be air cooled after forging without danger of cracking. However, if precipitation of carbides occurs during cooling through the range 1450 to 800 F corrosion resistance is reduced. Therefore parts that have been air cooled must be reheated to 2000 F and quenched in water to redissolve the carbides. Precipitation of carbides can be minimized or prevented by use of the stabilized grades, 347 and 321, or the extra low carbon grades.

Of the ferritic grades, type 430 can be readily hot worked. Although stiffer than mild steel, it is sufficiently malleable to be forged into complex shapes. The free machining modifications of 430 are not as readily formable as 430. Type 446 is more difficult

Some Applications of Stainless Steels

Throughout this manual, applications of the various grades have been mentioned in general terms. Consideration of the different factors will assist in narrowing the field, but it is not possible here to recommend a specific grade for a new application because selection must take into consideration all of the factors involved. However, service experience over a long period has indicated the areas of use to which the various grades are particularly applicable, and the table below includes some of these uses. Similarly, specific applications are illustrated in a number of photographs throughout the manual.

Austenitic Grades

201	Railroad car construction, wheel disks, truck trailer parts
202	Burner supports, flatware, pots and pans, building construction
301	Truck trailers, aircraft hose clamps, high strength applications in general
302	Exterior architectural uses, dairy equipment, food handling equipment, meat packing
302B	Annealing covers, burner sections, furnace and blower parts
303	Automatic screw machine parts such as fasteners
303Se	Automatic screw machine parts such as fasteners
304	Heat exchangers, chemical equipment, paper processing equipment, hospital equipment
304L	Sulphate digesters, cannery measuring hoppers, welded tanks
305	Evaporators, heat exchangers, refrigerator parts, chemical equipment
308	High-temperature plant equipment, industrial furnaces, welding rod
309, 309S	Heat exchangers, air heater tubing, incinerators, paper mill equipment, acid handling equipment
310, 310S	Heat exchangers, petroleum refining, chemical processing, gas turbines
314	Radiant tubes, annealing boxes, carburizing boxes, heat treating fixtures
316, 316L	Chemical equipment, photographic equipment, oil refining equipment, high pressure power plant equipment
317	Pharmaceutical and dyeing equipment
321	Aircraft collector rings, jet afterburners, exhaust stacks, welded construction
347	Expansion joints, high temperature boiler tubes, chemical equipment
348	Acid absorption towers, organic chemical storage tanks

Ferritic Grades

405	Stationary steam turbine blades that are not too highly stressed
430	Automotive trim, interior architectural trim, oil burner parts, hardware
430F	Automatic screw machine parts such as fasteners
430FSe	Automatic screw machine parts such as fasteners; hot and cold headed parts
446	Furnace parts, preheaters, annealing boxes, conveyor chains

Martensitic Grades

403	Steam turbine buckets, gas turbine compressor blades
410	Turbine blades, valve parts, pump shafts, fasteners, gratings
414	Airplane parts, flat springs, steering wheel spokes
416	Automatic screw machine parts such as fasteners
416Se	Automatic screw machine parts such as fasteners; hot and cold headed parts
420	Cutlery, lock washers, household appliances, loom parts
431	Aircraft stress members, forgings, nuts, bolts
440A	Cutlery, surgical and dental equipment, ball and roller bearings, valve parts
440B	Shear blades, surgical instruments
440C	Balls for valves and bearings, bearing races, valve seats and plugs

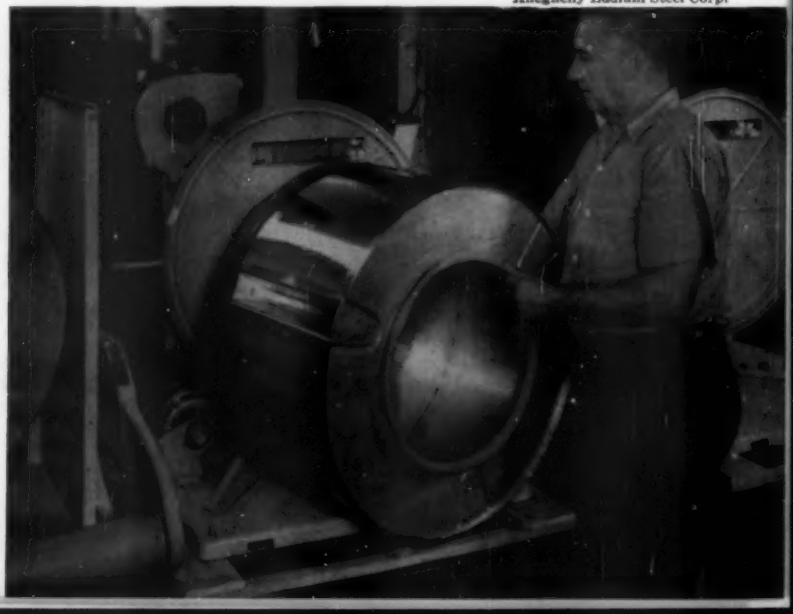
Domestic applications include . . .

***Aerosol container** for medicine.*

Allegheny Ludlum Steel Corp.

***Drum** for laundry dryer.*

Allegheny Ludlum Steel Corp.



to forge because its higher chromium content makes it less malleable than type 430.

Of the martensitic grades, type 410 is readily hot forged although it is more resistant to deformation than carbon steel at the forging temperatures and requires more or heavier hammer blows. Type 420 is more difficult to forge than 410 and should be used only for applications demanding additional strength. Cooling slowly from the forging temperature is necessary to prevent cracking resulting from air hardening. Types 440A, B and C are progressively more difficult to forge and must also be slowly cooled to prevent cracking.

Cold working

Although the austenitic grades can be cold formed readily, differences in work hardening cause differences in the amount of cold working that can be done without intermediate annealing. Types 302 and 304 can be drawn, formed, bent and upset easily. Type 301 work hardens rapidly and is used generally for high strength applications. Type 305 has a specially balanced composition to achieve a low rate of work hardening. It is used for spinning and single step deep drawing operations. Types 309 and 310 can be cold worked without difficulty although the higher alloy content makes them more resistant to deformation than the 18-8 types.

Of the ferritic grades, type 430 is particularly suited for cold forming operations such as spinning, blanking and forming. The alloy has deep drawing characteristics similar to those of mild steel but drawing requires slower application of pressure. Type 446 has lower ductility and is less readily cold formed.

Of the martensitic grades, type 410 can be cold headed, blanked, formed and drawn. Types 414 and 431 can be headed, blanked and formed in the annealed condition. Annealed type 420 can be moderately cold formed, and type 440 can be subjected to simple forming operations. The free-machining grades are not recommended for severe cold forming.

Welding

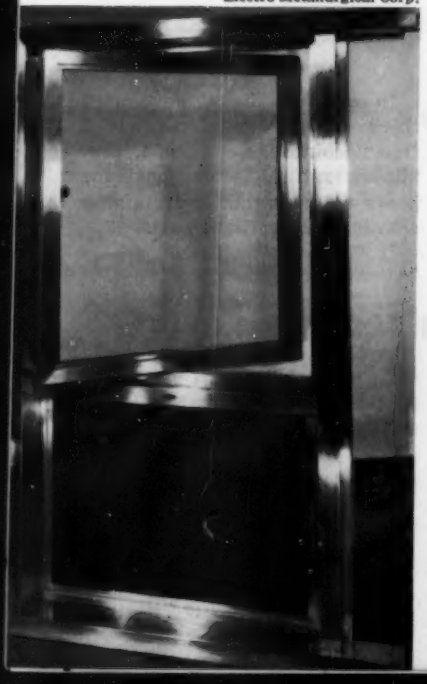
The stainless steels can be welded by any of the processes used with carbon steel except hammer or forge welding. Metal arc fusion welds are easy to make and are satisfactory for many jobs; inert-gas-shielded arc welding produces a smoother bead. Resistance spot and seam welding produce reliable, economical welds, particularly in light structures.

In the austenitic grades, corrosion resistance is affected by the welding heat in material heavier than 16-gage; these steels are susceptible to carbide precipitation as has been mentioned previously. If type 302 or similar grades with relatively high carbon content are welded, they will require reheating to put the carbides in solution to restore corrosion resistance unless they are quenched after welding. If reheating of the fabricated part is impossible and corrosive conditions are severe, the extra low carbon grades or the stabilized grades should be used. Types 309 and 310 can be welded without difficulty but require close procedural control because of high alloy content. The free-machining grades, 303 and 303Se, should not be used in parts that must be fabricated by welding.

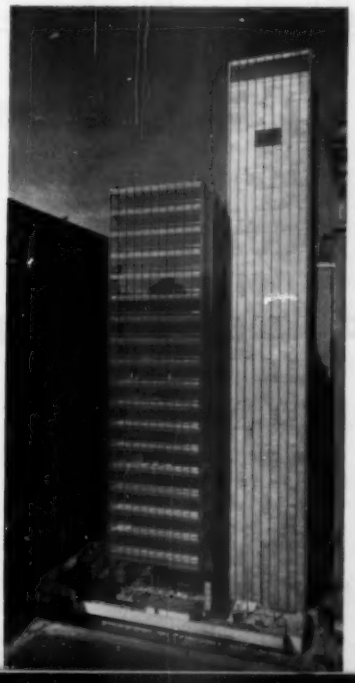
Of the ferritic grades, type 405

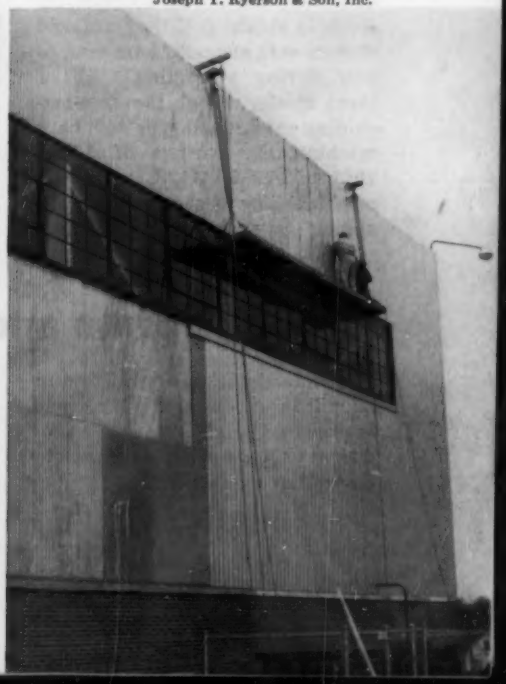
Architectural applications include . . .

***Curtain wall elements** such as reversible windows and spandrels.*
Electro Metallurgical Corp.



***Sheathing** for office buildings (left) and mill buildings (right).*
Joseph T. Ryerson & Son, Inc.





has been especially developed for welded parts that cannot be annealed after welding. Type 430 has good welding properties. The low ductility of type 446 introduces welding problems, but the welds are ductile at high temperatures. Welding of the free-machining grades is not recommended.

The martensitic alloys should be preheated before welding. Type 410 is usually annealed after welding to restore ductility. Types 420 and 440 are seldom welded because of air hardening tendencies, but have been joined using austenitic welding rods. Type 416, the free-machining modification, should not be welded.

Machining

The austenitic grades are more difficult to machine than the ferritic or martensitic grades because of their work hardening tendencies. All of the austenitic types, except type 303, have machinability ratings of 35 to 50% of AISI B-1112 (the free-machining carbon steel used as a basis of comparison for machinability); type 303 has a rating of 60%. Therefore, with the exception of type 303, these steels have about the same machining characteristics as medium carbon low alloy steels.

The ferritic and martensitic steels have similar machining properties, and are somewhat more readily machined than the austenitic grades. Best machinability in the straight chromium steels is obtained if they are cold drawn; soft annealed bars tend to tear during machining. All of these steels, except the free-machining grades and type 440, have machinability ratings of 50 to 70% of AISI B1112, and their machinability characteristics are similar to those of the medium carbon steels. Type 440 has a rating of 40% and resembles the alloy tool steels in machinability. The free-machining grades have machinability ratings of 80 to 90% of AISI B1112.

In each of the three groups there are two modifications of free-machining steels: one, containing sulfur, is designed for heavy cuts; the other, containing selenium, is for light cuts.

TABLE 3—AVAILABLE MILL FINISHES FOR STAINLESS STEEL SHEET

Finish ↓	How Obtained	Surface Appearance	Used as Final Finish for . . .	Can Be Used Before Fabrication When . . .
No. 1	Hot rolling, annealing and descaling	Frosty white	High temperature or industrial applications	Appearance not important or when surface will be marred, as in annealing
No. 2D	Cold rolling and descaling	Similar to No. 1, but brighter	Industrial applications	Severe drawing is to be followed by polishing
No. 2B	Cold rolling	Bright	Curtain walls; industrial, commercial and transportation equipment	Light forming is to be followed by polishing
No. 3	Polishing	Bright	Not generally used as final finish	A semifinished surface is required for final polishing after fabrication
No. 4	Polishing	Bright, good luster	Most commonly used finish: architectural trim; restaurant, kitchen and sanitary equipment	Forming operations will not mar surface
No. 6	Tampico brushing	Soft, satiny	Decoration without high reflectivity	
No. 7	Polishing and buffing	High luster	Decoration	
No. 8	Polishing and buffing	Mirror finish	Decoration or a reflective surface	

TABLE 4—COMPARABLE PRICES OF STAINLESS GRADES
(Type 302 = 100)

Type ↓	Hot Rolled Strip	Sheet	Hot Rolled Rods; Cold Finished Wire	Bars; Structural Shapes
201	89	94	94	94
202	96	95	96	96
301	92	99	99	99
302	100	100	100	100
304	110	103	103	107
309	160	155	105	150
310	209	187	204	204
316	172	158	161	163
410	77	78	75	75
420	103	105	92	92
430	79	79	76	76
446	146	136	102	104

4. What forms and sizes will be required?

Stainless steels are available in all mill forms, but not every grade is produced in all forms. The producers should be consulted to determine availability.

The most widely used forms are sheet and strip. Steel mills classify pieces 2 ft wide or wider as sheet, pieces less than 2 ft wide as strip. Sheets are available in standard sizes up to 4 by 10 ft and thicknesses ranging from 0.010 to 0.186 in. from warehouse stocks. Larger sizes and thinner stock (down to 0.001 in.) can be ob-

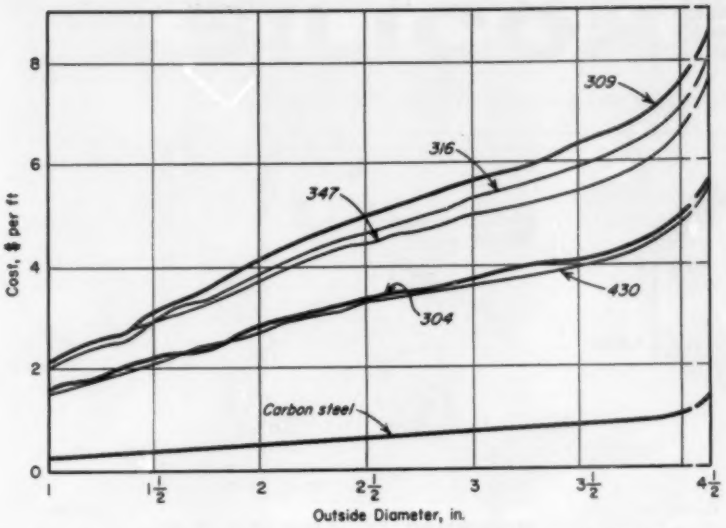


***Fig 12**—Cost of tubing varies with the grade but all grades of stainless are considerably more expensive than carbon steel.* (*Metal Progress*, Aug 15, '55)

tained on order from the mills. Strip is sold in cut lengths or coils in thicknesses down to 0.001 in.

Plate (by definition, flats 3/16 in. and over in thickness) can be obtained in stainless or stainless-clad. Although stainless-clad is commonly produced as mild steel clad on both sides with stainless steel, other claddings with nonferrous metals are also available.

Tubing is available in seamless or welded form. Sizes range from a few thousandths of an inch (hypodermic tubing) to 36 in. Square, rectangular and special-shaped tubing can also be obtained.

Bars are obtainable in hot rolled or cold finished form, wire in annealed or drawn tempers. Some structural shapes, special extrusions, and perforated and expanded forms are also commercially available.

Certain finishes, varying with the product, are regularly supplied by the mills. Those applicable to sheet are shown in Table 3.

In addition to these forms, various stainless grades can be obtained in fabricated parts, fasteners and fittings.

5. What are the cost factors?

The first point to be considered here is whether stainless steel is required. For some corrosive conditions and types of service, it is cheaper to use mild steel and replace it periodically. Fig 12 gives an indication of the relative costs of carbon steel and stainless steel tubing, and it is apparent that there is quite a spread between them.

Assuming that stainless steel is required, it should be axiomatic that the proper grade to select is the least expensive one that will adequately fulfill the requirements of corrosion resistance, properties and fabrication. For example, if type 430 will serve adequately, why pay extra for type 302?

Table 4 compares the prices of various grades using type 302 as the basis. The table shows that the prices vary from ¾ to 2 times that of type 302. Incidentally, the

Sources of Additional Information

In a manual of this size, it is possible only to touch lightly on the various properties and fabrication procedures. Additional information can be obtained from publications such as the following:

Binder, W. O., "The Resistance of Wrought Stainless Steels to Corrosion," *Metals Handbook*, 1948 ed., pub. by American Society for Metals, Cleveland, Ohio, p 557.

Clauser, H. R., "Materials for High Temperature Service," MATERIALS & METHODS Manual No. 104, Apr '54, p 117.

Everhart, J. L., "Age Hardenable Metals," MATERIALS & METHODS Manual No. 109, Oct '54, p 121.

Krivobok, V. N., Mayne, C. R., McKelvey, A. J., and Paret, R. E., *Forming of Austenitic Chromium-Nickel Stainless Steels*, pub. by International Nickel Co., New York, N. Y.

Lævy, A., "Metals for Short Time Service at High Temperatures," MATERIALS & METHODS Manual No. 115, Apr '55, p 117.

Paret, R. E., "How to Finish Stainless Steel," *American Machinist*, Nov 7, '55, p 129.

Paret, R. E., "Selecting Mechanical Finishes for Stainless Steels," M/DE, Sept '57, p 110.

Roach, D. B., and Hall, A. M., *The Engineering Properties of Precipitation Hardenable Stainless Steels*, TML Report No. 48, pub. by Battelle Memorial Inst., Columbus, Ohio.

Roach, D. B., and Hall, A. M., "New Stainless Steels," MATERIALS & METHODS Manual No. 126, Apr '56, p 137.

"Selection and Application of Stainless Steel in the Chemical Process Industry," *Metal Progress*, Aug 15, '55, p. 37.

Simmons, W. F., and Cross, H. C., *Report on the Elevated Temperature Properties of Chromium Steels (12-27%)*, STP No. 228, pub. by Am. Soc. for Testing Materials, Philadelphia.

Simmons, W. F., and Cross, H. C., *Report on the Elevated Temperature Properties of Stainless Steels*, STP No. 124, pub. by Am. Soc. for Testing Materials, Philadelphia.

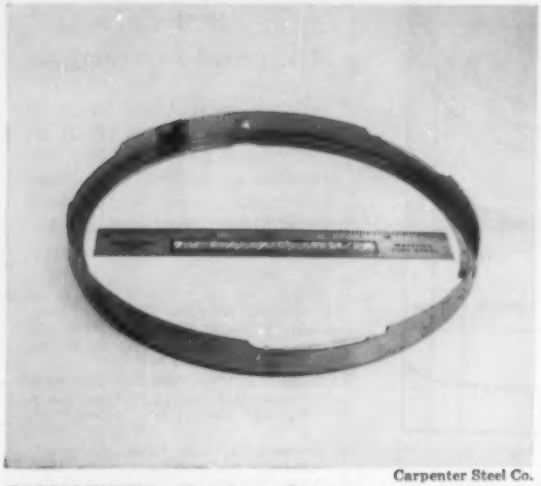
Simmons, W. F., and Krivobok, V. N., *Compilation of Chemical Compositions and Rupture Strengths of Super-Strength Alloys*, STP No. 170-A, Am. Soc. for Testing Materials, Philadelphia.

Stainless and Heat Resisting Steels, Steel Products Manual, pub. by Am. Iron and Steel Inst., New York, N.Y.

"Stainless Steels," *Metal Progress*, July 15, '54, p 34.

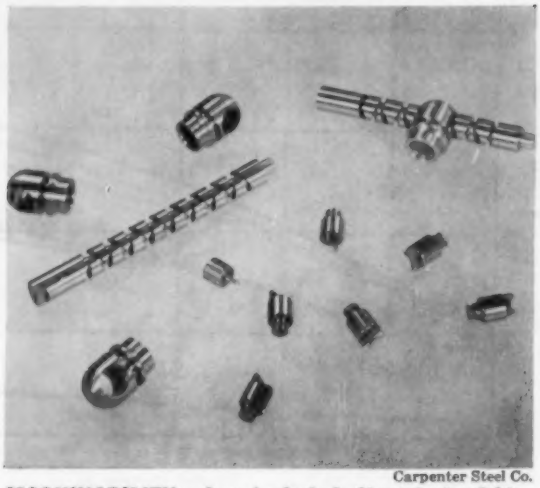
In addition to these specific publications, many of the steel producers have published excellent handbooks. Among these companies are Allegheny Ludlum Steel Corp., Armco Steel Corp., Carpenter Steel Co., Crucible Steel Co. of America, Eastern Stainless Steel Corp., Republic Steel Corp., and United States Steel Corp.

Fabricating properties influenced selection in these applications



Carpenter Steel Co.

FORMABILITY—Retainer ring *for watthour meter is produced from type 304 for clean blanking and easy formability.*



Carpenter Steel Co.

MACHINABILITY—Level-wind shaft parts *for fishing reels are produced from type 416 to eliminate expensive hand finishing.*

Allegheny Ludlum Steel Corp.

WELDABILITY—Manifolds *for diesel locomotives are produced from type 321 to obtain stabilized structure.*

Carpenter Steel Co.

HARDENABILITY—Jet engine parts *are produced from types 440A and 440C to utilize the highest hardness values obtainable in the stainless steels.*

table also indicates that there is considerable price variation in a single grade depending on the mill form.

Acknowledgments

The author is particularly indebted to Richard E. Paret, Stainless Steel Committee, American Iron and Steel Institute, and to Kenneth A. Matticks, Crucible Steel Co., for criticizing the manuscript and offering many helpful suggestions. The author also wishes to acknowledge the assistance received from the personnel and publications of the following organizations:

Allegheny Ludlum Steel Corp.
American Iron and Steel Institute, Stainless Steel Committee
Armco Steel Corp.
A. M. Byers Co.
Carpenter Steel Co.
Eastern Stainless Steel Corp.
Electro Metallurgical Corp.
Crucible Steel Co. of America
International Nickel Co., Inc.
Jessop Steel Co.
Jones & Laughlin Steel Corp.
Latrobe Steel Corp.
Lukens Steel Co.
Republic Steel Corp.
Joseph T. Ryerson & Son, Inc.
Sharon Steel Corp.
Superior Steel Corp.
Superior Tube Co.
United States Steel Corp.
Universal-Cyclops Steel Corp.

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SILICONE NEWS

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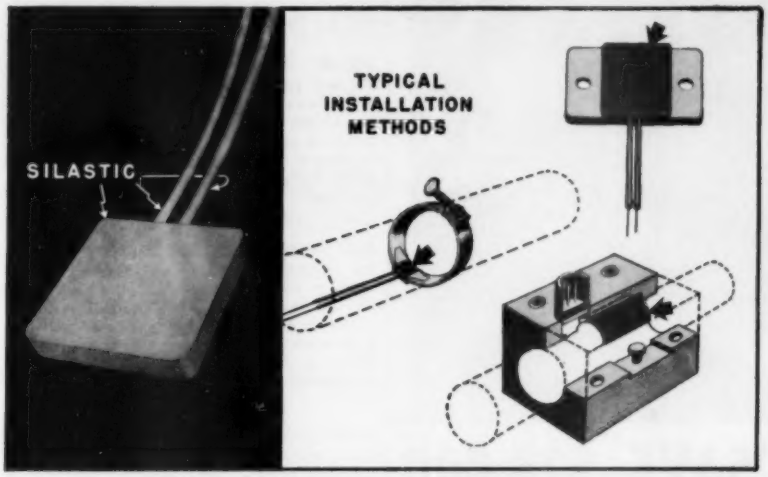


OFFSETS TOUGH SURROUNDINGS

Even the most delicate instruments can be counted on to give reliable service in hazardous surroundings when protected with Silastic®, the Dow Corning silicone rubber. Here's how encapsulation in Silastic seals in better performance.

The new Strapon surface resistance thermometer, recently developed by Arthur C. Ruge Associates, Inc., Cambridge, Mass., illustrates this point. Consisting of a resistance element bonded to a stainless steel surface only 0.002 inches thick, the thermometer and lead-in wires are fully cushioned and protected against the elements by Silastic, the Dow Corning silicone rubber.

Silastic protects this thermometer at temperatures ranging from —100 to 500 F... assures accuracy in the presence of vibration, radioactivity, high humidity, water, alcohols, salts, mineral and vegetable oils, many acids and alkalies. As a result, Strapon thermometers are used to measure surface temperatures in applications ranging from in-flight missile testing to flow control monitoring for the food and chemical processing industries.

For easy mounting on any surface, Strapon thermometers can be bonded to a variety of clamps and brackets with Silastic adhesive. *No. 593*

BETTER MOISTURE SEAL

When long-lasting silicone compounds are employed, sealing is frequently made easier and more effective. Wico Electric Company, West Springfield, Mass., furnishes an example.

Wico manufactures magneto coils for the ignition systems of gasoline engines on popular-make outboard motors, chain saws, lawn mowers and other gasoline-engine driven products. Moisture, corona and corrosion at the connection between high tension lead wire and coil has always been a problem.

Keeping moisture out, however, has been easy since Wico started using Dow Corning 3 Compound. Applied liberally on the lead, the greaselike silicone compound lubricates mating parts . . . flows readily into existing voids when the ignition lead wire is screwed into place in the magneto coil body. The result is a moistureproof seal between the neoprene jacketed ignition lead and the molded plastic body.

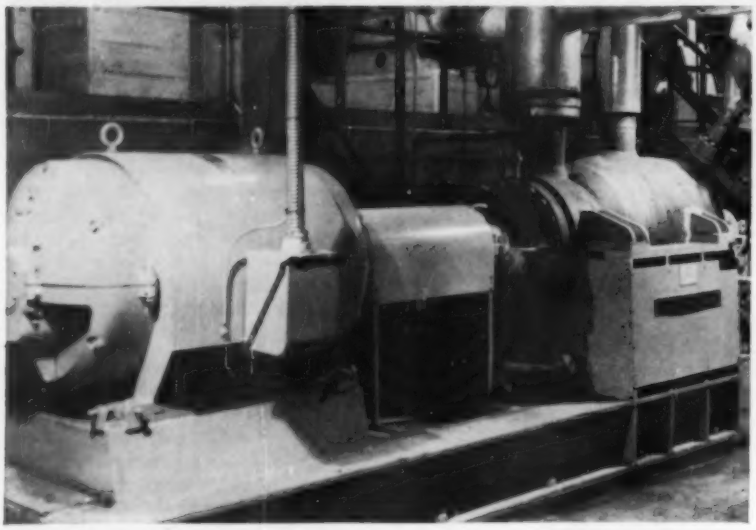
Nonoxidizing, nonmelting and nongumming, this silicone compound protects indefinitely against moisture, corona and corrosion, and is noninjurious to rubber or plastics. If the ignition lead is removed for repair or replacement, the connection is easily re-sealed with another application of Dow Corning 3 Compound. *No. 594*

New: 1959 Guide To Silicones

Now available. The 1959 Reference Guide to all Dow Corning silicone products, including fluids, lubricants, resins, adhesives, varnishes, dielectrics, rubber, water repellents, textile finishes, leather treatments and other specialized forms. A "must" for designers, you can obtain your Free Copy by circling . . . *No. 595*

New Aid For Missilemen

For product designers whose projects are related to missilery, the new brochure "Silicones in Missile Design" offers practical information on silicones and their uses. Particular attention is devoted to areas that point up how silicones aid miniaturization, weight reduction, and reliability. *(Cont. Pg. 2)*



MODIFY SPECS: SAVE $28,000

Designers of pumps, fans, blowers and compressors can often cut costs and improve reliability by specifying silicone insulated drive motors. Here's how modifying the specification to include silicone insulation saved 38% on the original cost of four large motors.

Intended for service in a dusty, humid atmosphere, totally-enclosed, fan-cooled construction was originally specified for pump and fan drive motors. These costly enclosures were specified to isolate the induction motor's stator coils from the contaminated atmosphere.

A far more economical solution was found through the use of open, drip-proof enclosures. Sil-Clad motors, built by Electric Machinery and Manufacturing Company with silicone rubber insulated coils, had self-protecting insulation systems that made less costly motor enclosures adequate. A savings of $28,000 resulted for the Minnesota and Ontario Paper Company, International Falls, Minnesota. What's more, the motors have an even greater service factor (overload capacity) than the originally-specified drives because of the excellent thermal stability of Dow Corning Silicones.

Electric Machinery's self-protecting insulation system is fabricated by double-wrapping coils with semi-vulcanized tape made from Silastic®, the Dow Corning silicone rubber. The tape system is then cured, forming a resilient, moistureproof, one-piece insulating jacket with excellent dielectric properties.

This $28,000 saving resulted from specifying silicone insulation systems for only four motors. Two are 900-hp boiler feed pump motors, the third a 600-hp induced draft fan motor, and the fourth, a 300-hp forced draft fan drive motor. *No. 596*

MISSILES *(Continued)*

The new eight-page brochure covers all physical forms of Dow Corning Silicones . . . rubbers, resins, dielectrics, fluids, greases and compounds.

Fully illustrated, the brochure describes how missile components are already utilizing silicones, and suggests many new areas of application. It is organized for easy reference, enabling you to locate, at a glance, any material or application that interests you. All in all, a very valuable brochure. Free on request . . . *No. 597*

new literature and technical data on silicones

DO YOU KNOW HOW silicone resins, rubber, oils and greases are being used to advantage in appliances? A six-page reprint from *Electrical Manufacturing* relates how extreme temperature resistance properties of silicones have been used to improve the performance of toasters, refrigerators, irons, portable power tools, percolators and other appliances. *No. 598*

KEEP 'EM COOL WITH SILICONE FLUIDS. Designers of electronic assemblies are using silicone fluids as coolants to solve problems created by extreme environmental conditions and miniaturization in control circuitry of aircraft, missiles, submarines, and industrial communication systems. A new data sheet contains complete information for designers. *No. 599*

THREE TO ONE . . . Sylkyd® magnet wire enamel is equally suitable for 180 C, 155C, and 130 C electrical systems. Wire enameled with Sylkyd enables equipment to withstand overloads, provides more power per pound, has longer shelf life, and withstands difficult operating conditions. Excellent size factor and good handling properties simplify design. Further information is available in a 4-page, illustrated brochure. *No. 600*

THE PROS AND CONS of reactive silicone resin intermediates in paints and varnishes are presented in an eight-page reprint from *Paint and Varnish Production*. Graphs and tables illustrate how resistance of copolymers to heat and weathering, as well as film integrity and strength, are improved by silicones. *No. 601*

COMPLETE SELECTOR — Recognized for their reliable, uniform performance in viscous damping, springing, coupling, and related mechanical applications, silicone fluids are now easy to select because of an up-to-date, file-size engineers' guide. Published as a design service by Dow Corning, this reference is a "must" for advance development research engineers. *No. 602*

SOLVENTLESS, THERMOSETTING RESINS. Dow Corning R-7501 and R-7521 are clear, tough silicone materials used for impregnating, encasing, and potting electrical and electronic units designed for high service temperatures. Used separately or blended to any desired viscosity, the good physical and electrical properties, water resistance, and heat conductivity of these resins suggest their usefulness in fabricating cast dies and molds, as components or additives for other resins used to formulate protective coating vehicles or molding compounds. *No. 603*

Dow Corning Corporation, Dept. 7013, Midland, Michigan

Please send me: 593 594 595 596 597 598 599 600 601 602 603

NAME _____

TITLE _____

COMPANY _____

STREET _____

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MIDLAND, MICHIGAN

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FILE FACTS

Recommended Design Tolerances for Plastics Moldings

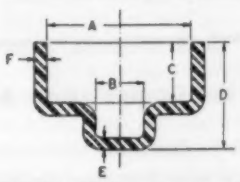
Asbestos-Woodflour-Filled Phenolic

Drawing Code	Dimensions (in.)	Fine ±	Standard ±	Coarse ±
A = Diameter or Length B = Diameter or Length C = Depth	6.000 to 12.000	0.0015	0.002	0.0025
	For each inch over 6.000 add (in.)			
	Over 12.000	0.002	0.003	0.005
	For each inch over 12.000 add (in.)			
HEIGHT D	Single Cavity 0.000-1.000	0.004	0.006	0.008
	Multiple Cavity 0.000-1.000	0.006	0.008	0.010
	For each inch over 1.000 add (in.)	0.002	0.003	0.005
BOTTOM WALL E	0.000 to 0.100	0.003	0.005	0.008
	0.100 to 0.200	0.003	0.005	0.008
	0.200 to 0.300	0.003	0.005	0.008
SIDEWALL F DIMENSION [b]		Section thickness to be held relatively constant		
F Variation in wall thickness due to eccentricity,		0.005-0.007 in. Interlocking reduces this.		
DRAFT ALLOWANCE		1/8°	1/4°	1°

Plus or Minus in Thousands of An inch[a]

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

FINE · STANDARD · COARSE



[a] These tolerances do not apply to screw threads, gear teeth or fit of mating parts; dimensions in these classifications can generally be held to closer limits. These tolerances do not include allowance for aging characteristics of material

[b] For further information see discussion in Plastics Engineering Handbook.

DWG. CODE			
D, E	Compression molded. For projected area over 20 sq. in.	Fine	Add 0.001 in. for each additional 10 sq. in.
		Standard	Add 0.002 in. for each additional 10 sq. in.
		Coarse	Add 0.003 in. for each additional 10 sq. in.
	Transfer, Jet, or Injection molded. Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (F = Fine; S = Standard; C = Coarse)	
		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	
D	Single cavity	F S C	
D	Multiple cavity	F S C	
D	For each inch of depth over 1.000 add (in.)	0.001	

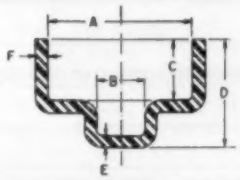
Macerated Paper-Filled Phenolic

Drawing Code	Dimensions (in.)	Fine ±	Standard ±	Coarse ±
A = Diameter or Length B = Diameter or Length C = Depth	6.000 to 12.000	0.002	0.0025	0.003
	For each inch over 6.000 add (in.)			
	Over 12.000	0.002	0.004	0.006
	For each inch over 12.000 add (in.)			
HEIGHT D	Single Cavity 0.000-1.000	0.008	0.010	0.012
	Multiple Cavity 0.000-1.000	0.010	0.012	0.014
	For each inch over 1.000 add (in.)	0.002	0.005	0.008
BOTTOM WALL E	0.000 to 0.100	0.003	0.005	0.008
	0.100 to 0.200	0.003	0.005	0.009
	0.200 to 0.300	0.003	0.006	0.011
SIDEWALL F DIMENSION [b]		Section thickness to be held relatively constant		
F Variation in wall thickness due to eccentricity,		0.005-0.007 in. Interlocking reduces this.		
DRAFT ALLOWANCE		1/8°	1/4°	1°

Plus or Minus in Thousands of An inch[a]

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

FINE · STANDARD · COARSE



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	Transfer, Jet, or Injection molded. Any area	PLUS OR MINUS TOLERANCE IN THOUSANDTHS OF AN INCH (F = Fine; S = Standard; C = Coarse)	
		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	
D	Single cavity	F S C	
D	Multiple cavity	F S C	
D	For each inch of depth over 1.000 add (in.)	0.0015	

Source: *Plastics Engineering Handbook* of the Society of the Plastics Industry, Inc., Reinhold Publishing Corp., 1954.

◀ For more information, circle No. 422

You still have time to enter M/DE's . . .

3rd Annual Awards Competition

for the Best Use of Materials in Product Design

Enter any new product or redesigned product, assembly, subassembly or single part that shows sound, imaginative or progressive use of engineering materials.*

**Engineering materials: metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.)*

16 CASH AWARDS

FIRST AWARD $500 and plaque

FIVE AWARDS OF MERIT $100 each and certificate

TEN CITATIONS $50 each and certificate

Rules of the Competition: A Brief Summary

(For more complete details, see the December issue, pp 115-8)

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1958.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *February 2, 1959.*

For description of last year's award winners see Apr '58 issue, pp 127-58.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., N. Y. 22, N. Y.

Name _____ **Title** _____

Name(s) of person(s), group or organization who would receive award _____

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Company _____

Street address _____ **City** _____ **State** _____

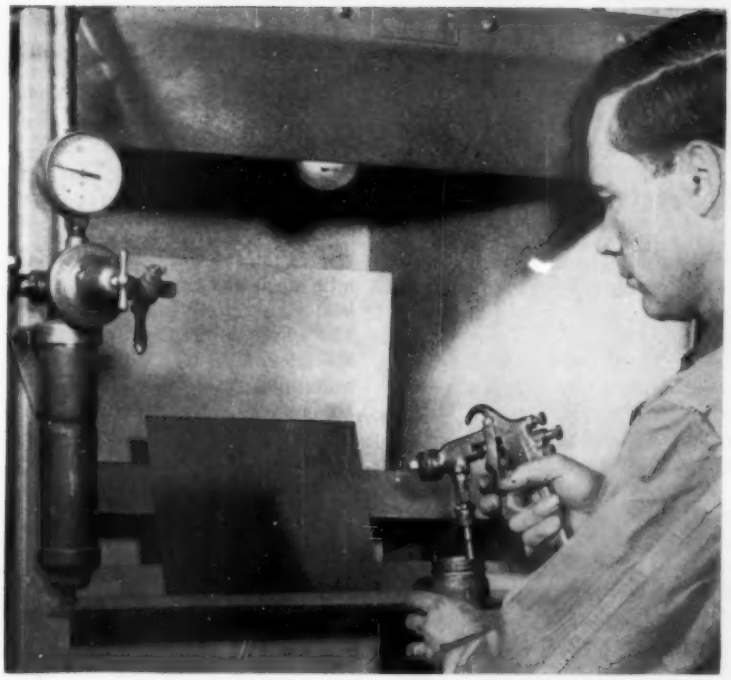
Name or brief description of product being entered _____

_____

Was design (or redesign) of entry either completed or placed in production during 1958? _____

Does your employer consent to entry under terms of this competition? _____

Edited by
John A. Mock



Spraying TFE dispersion *on an aluminum panel. The dispersion cannot be brushed or dipped because these techniques cause pigment in the dispersion to agglomerate.*

TFE Films Can Be Sprayed on Wood, Rubber, Plastics

■ TFE films can now be applied to wood, rubber, plastics and many other heat sensitive materials by using two new TFE dispersions. One, called Emralon 310, cures at a temperature of 300 F or less; the other, called Emralon 320, cures at room temperature. Formerly, TFE films could be used only on materials that could withstand the sintering temperature of 700 F.

Developed by Acheson Colloids Co., Port Huron, Mich., the new dispersions are applied by spray equipment. (Last summer Du Pont announced a TFE dispersion that could be applied by electrodeposition; see M/DE, June '58, p 141.) Acheson is offering introductory packages of its TFE dispersions at a price of $4.25. Each package contains enough material to coat 5000 sq in. of surface.

Many potential uses

The TFE dispersions have many potential uses as coatings for industrial and non-industrial products. For instance, the collection of dirt, excessive grease and corrosive elements on industrial machinery can be avoided by using the dispersions. Other application possibilities include coatings for molds, drums, extrusion dies, gaskets, bearings and conveyors.

The dispersions should find use on many household products, including window casings, desk drawer guides, furniture casters, toilet mechanisms, shoe scrapers, door hinges, sliding closet doors, ice cube trays, laundry chutes and garden tools.

The TFE dispersions should also be useful for military and hunting arms, gasoline and fuel injector pumps, playground slides, parking meters, cash registers, speedometer cables, skis, skates, toboggans, farm machinery, business machines and automobile engine parts. (For information on the use of TFE films for lubricating and preserving military weapons and ammunition, see M/DE, Aug '57, p 147.)

Emralon 310

Described as a dispersion of TFE resin in a phenolic binder, Emralon 310 can be cured in 1 hr at 300 F. The dispersion has a flash point of 46 F, a density of 8.2 lb per gal, and a shelf life (as

shipped) of 2 months. Emralon 310 has a liquid consistency.

Film properties—According to the developer, properly cured films of Emralon 310 show a significant improvement in wear life over fused TFE films. Other characteristics of the films are:

1. Coefficient of friction of 0.05 to 0.07.

2. Good corrosion resistance. An Emralon 310 film, when applied to a mild steel and a cadmium electroplate, shows good resistance to salt spray after aging 300 hr. For maximum corrosion resistance on steel a phosphate pretreatment is recommended.

3. Good resistance to hydraulic fluids, oils and conventional solvents; strong polar solvents such as esters and ketones should be avoided.

4. Resistance to a temperature of 400 F intermittently and 350 F continuously.

Emralon 320

According to the developer, Emralon 320 is an air drying dispersion and is designed for use where baking is not practical. It is described as a pigmented, resin-bonded dispersion. The dispersion has a flash point of 40 F, a density of 7.9 lb per gal, and a shelf life (as shipped) of 2 months.

Film properties—Films formed from the dispersion have a coefficient of friction of 0.05 to 0.07. For maximum corrosion resistance on ferrous substrates the producer recommends that a phosphate pretreatment be used. The coating can be used in contact with some weak solvents; however. strong solvents should be avoided because they will soften and destroy the film.

Savings up to 35% possible with . . .

Four High Strength Mild Carbon Steels

■ Four new, high strength, mild carbon steels which are said to cost up to 35% less than similar steels presently being used have been developed by Great Lakes Steel Corp., a subsidiary of National Steel Corp. The most significant aspect of the new development is the fact that the steels offer superior yield strength and weldability with no loss in ductility.

Composition and properties

According to Great Lakes, the combination of high yield strength and good ductility results from a new columbium treatment and the reduction of carbon and manganese in the analysis. The columbium treatment produces a fine-grained internal structure in the hot rolled steel. Refinement increases with increasing columbium additions, and it is this grain refinement that produces high yield strengths, tensile strengths and toughness. Heretofore, this structure has been obtained by the use of expensive alloying elements in substantial quantities and by various heat treatments.

Although complete details on composition and columbium treatment were not released, carbon content is said to be kept to about 0.15-0.20%. The amount of columbium retained in the final analysis has not been disclosed. The company says that "at any given carbon and manganese content, the addition of columbium will raise the yield strength by as much as 20,000 psi and the tensile strength by about 15,000 psi."

The new steels are classified according to their yield strengths as follows: GLX-45-W (45,000 psi), GLX-50-W (50,000 psi), GLX-55-W (55,000 psi) and GLX-60-W (60,000 psi). A comparison of tensile properties between these steels and a mild carbon steel not treated with columbium is given in Table 1.

Weight and cost savings

According to Great Lakes, the new GLX-W steels should occupy a position between the common mild steels and the more expensive low alloy, high strength steels. The company points out that the low alloy, high strength steels are sometimes too good for many applications. For example, there are many uses in which the relatively good corrosion resistance of these steels is not required,

TABLE 1—TENSILE PROPERTIES OF GLX-W STEELS

Type ↓	Ten Str, 1000 psi	YldPoint, 1000 psi	Elong, %
GLX-45-W	70	47	43
GLX-50-W	73	55	37
GLX-55-W	78	58	35
GLX-60-W	82	63	34
Untreated Steel	62	37	44

TABLE 2—WEIGHT REDUCTIONS AND COST SAVINGS

Form ↓	Plate Thickness for Equal Strength, In.	Weight Reduction, %	Price per 100 Lb, $	Cost Reduction, %
Flat Sections				
Mild Steel	0.500	—	6.15	—
GLX-50-W	0.385	23	7.15	10.4
Half Circles				
Mild Steel	0.500	—	6.15	—
GLX-50-W	0.330	34	7.35	20.8
Pressure Vessels				
Mild Steel	0.333	—	6.15	—
GLX-50-W	0.200	40	7.50	26.8

and a premium price is being paid for unnecessary properties. Because the new steels are stronger than the common mild steels, the necessity of using the more expensive steels is not only eliminated but substantial weight reductions are made possible in many applications.

Some examples of weight reductions, and hence decreased costs, are given in Table 2 for flat sections, hollow half circles used in beams, and pressure vessels.

Fabrication

Formability—The new steels are said to be as readily formed as the best of the low alloy, high strength steels. The ratio of blank diameter to depth of draw is about 2 to 1.

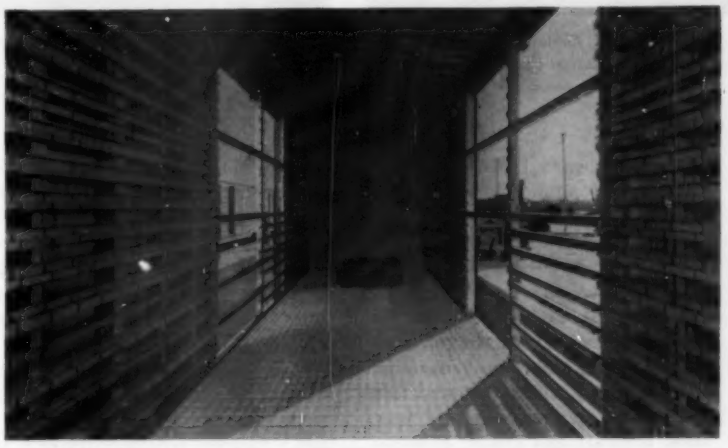
Weldability — Because carbon and manganese contents are low, weld cracking does not occur in the new steels even when welded at temperatures as low as –40 F. Also, columbium reduces the tendency toward underbead cracking.

Availability

The new steels are commercially available and are being produced in plate, bar and shapes similar to those obtainable in mild steels. Thin sheet is not yet available, but is expected in the near future.

Some uses of GLX-W steels include . . .

. . . earth moving equipment . . .



. . . truck frames . . .

. . . and pressure vessels.

Potassium Titanate Fibers Insulate Well at 2200 F

■ Latest of a number of high temperature thermal insulations developed in recent months, fibrous potassium titanate is expected to be useful up to 2200 F.

Fibrous potassium titanate is being produced on a semi-works scale and is now available from E. I. du Pont de Nemours & Co., Inc., Pigments Dept., Specialty Products Section, Wilmington 98, Del. It is supplied as loose fibers, mats and blocks. The product is sold in experimental quantities at $12 per lb in lump form. Du Pont expects the price to drop considerably once production gets going.

Many potential uses

According to J. B. Sutton, sales manager of the Specialty Products Section, fibrous potassium

Cylinder *of fibrous potassium titanate is fabricated by wrapping a wet mat around a form.*

Worker's hand *is protected from heated copper rod by thin coating of Du Pont's thermal insulation. The product can be trowled onto any irregular surface when combined with water.*

titanate appears best suited for insulating applications where space and weight are critical. In the 1300 F to 2100 F range, it is about twice as effective on a volume basis as any known insulating material, he says.

As a thermal insulator at high temperatures, fibrous potassium titanate may offer construction advantages for rockets and missiles, aircraft and atomic-powered vehicles. Suggested but as yet untried applications include its use as an insulation for missile nose cones and rocket combustion chambers.

Other suggested applications for the material include electrical and acoustical insulations, reflective shielding for heating units and ovens, gaskets and packings, filters, fire blankets and protective clothing. The material may also be useful as a filler for paper, as a pigment for paints, and as a reinforcement for plastic resins.

PROPERTIES OF FIBROUS POTASSIUM TITANATE

PHYSICAL PROPERTIES	
Melting Point, F	2500
Theoretical Density, lb/cu ft	200
Moisture Pick-Up, %	
47% RH	0.34
90% RH	1.70
ELECTRICAL PROPERTIES	
Dielectric Constant (100 kc)	
77 F	3.5
392 F	3.5
572 F	3.7
Dissipation Factor	
77 F	0.06
392 F	0.06
572 F	0.09
Resistivity, ohm-cm	
77 F	3.3×10^{15}
392 F	3.2×10^{9}
572 F	3.4×10^{6}

Properties

Thermal conductivity — A fibrous potassium titanate block with a density of 12 lb per cu ft has a thermal conductivity of 0.38 Btu/hr/sq ft/°F/in. at 500 F; at 1000 F the figure is 0.53. The low thermal conductivity of the insulating material is due in large part to the high refractive index of the fibers and to their dimensions (1 μ in dia); these qualities serve to block infrared radiation by diffuse reflectance. Compacts of the fibers offer high resistance to heat transfer even at low bulk densities, according to Du Pont.

Density—The normal density of the insulating material is 12 to 15 lb per cu ft for formed blocks. Higher densities can be obtained by pressing the wet mats and drying. Blocks with a density of approximately 70 lb per cu ft can be made by pressing at 2000 psi and drying under pressure.

Dimensional stability — Blocks of fibrous potassium titanate show exceptional dimensional stability after 6 days' aging at 1900 F. A test muffle furnace was insulated with the material and operated continuously and in cyclic fashion for over a year at temperatures up to 2200 F. No shrinkage of the insulation was observed. Power input to maintain a given temperature in the

MORE WHAT'S NEW IN MATERIALS

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3500°F

AND ONLY

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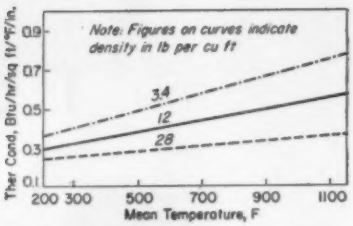


***Thermal conductivity** of fibrous potassium titanate.*

furnace remained constant over the test period.

Fabrication

Du Pont says potassium titanate fibers can be processed readily into blocks (mats), papers and loose fibers. Blocks or mats of varying bulk densities can be prepared from water dispersions of the fibers by felting on a screen, using pressure or vacuum filtration. Blocks and papers formed in this manner are said to have adequate strength for most applications without the use of binders. Curved or odd shapes can be formed from the wet mats, which hold their shape when dried.

Other thermal insulations

Other high temperature thermal insulations discussed in recent issues of this magazine include: 1) refractory fiber felt (Nov '58, p 180), 2) silica foam (Sept '58, p 129), 3) silica-asbestos (May '58, p 143), and 4) asbestos-silicone (May '58, p 170).

High strength at 1400 F claimed for . . .

Precipitation Hardening Steel

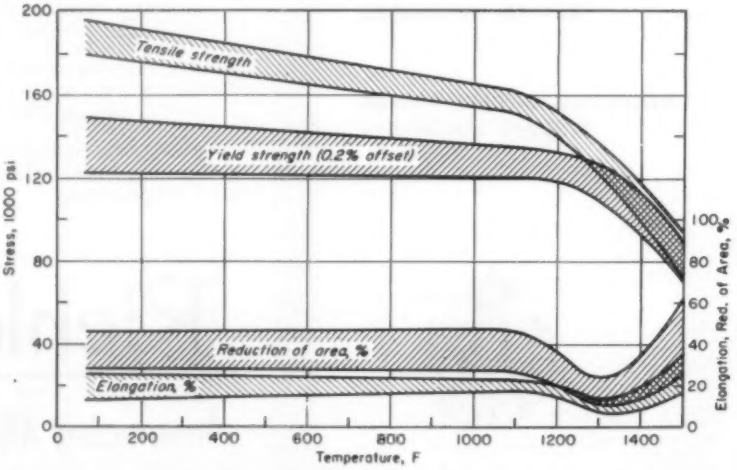
■ A new precipitation hardening steel that is said to maintain high strength and corrosion resistance at 1400 F has been developed by Universal-Cyclops Steel Corp. The new alloy, called Unitemp 212, is expected to find applications in the aircraft and guided missile fields.

Composition

The new steel is described as an austenitic iron-nickel-chromium alloy made heat treatable by the addition of titanium. Small amounts of columbium, boron and zirconium are added to retard the over-aging reaction which is characteristic of alloys of this type. These additions are also said to improve the inherent notch sensitivity in rupture which generally accompanies increases in titanium content. For complete analysis, see Table 1.

Properties

Tensile properties — Typical and minimum tensile properties are given in Table 2. As shown, the al-



***Short-time tensile properties** of Unitemp 212 bar and sheet in the solution treated and aged condition.*

For more information, circle No. 363 ➤

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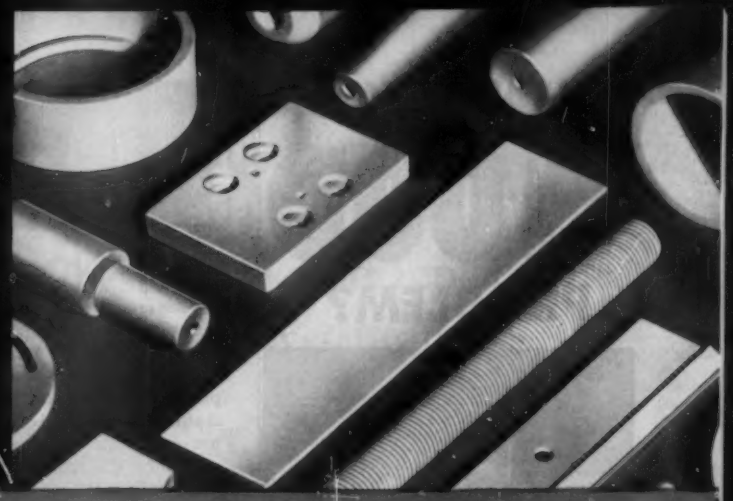

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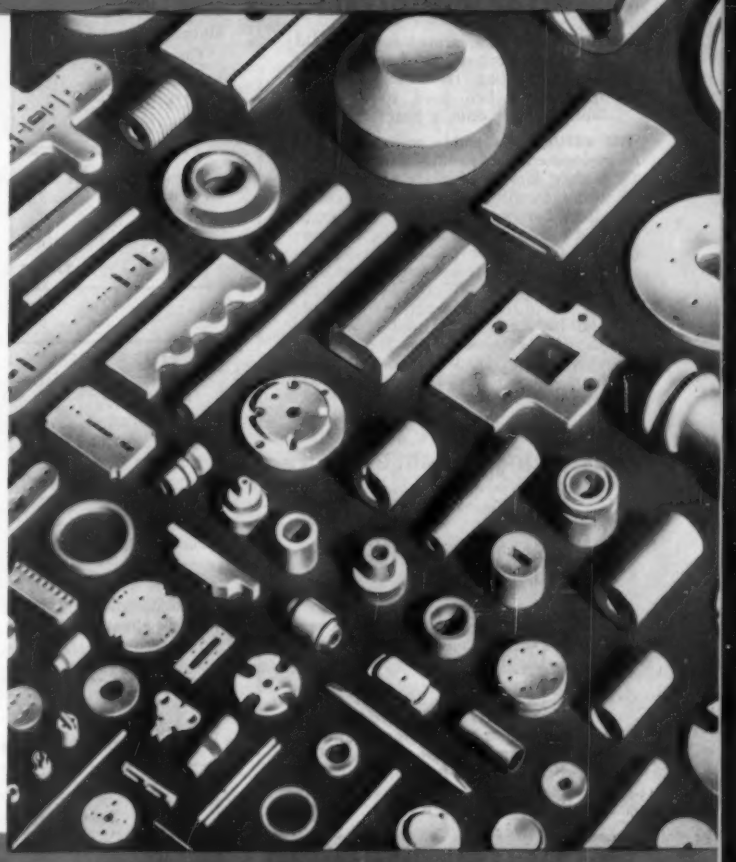

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loy retains fairly high strength at temperatures up to 1400 F. Yield strength is particularly good, and Universal expects the alloy to replace the precipitation hardening stainless steels and the 5% chromium die steels (which drop off considerably in strength at 1400 F) for many aircraft and missile applications.

In addition to high temperature strength, Unitemp 212 offers good properties for sub-zero applications. Tensile data at —320 F are given in Table 3 for bar and sheet. The combination of high yield strength and good ductility should make the alloy useful in low temperature applications where strength and impact resistance are required.

Corrosion resistance — According to Universal, the oxidation resistance of Unitemp 212 is similar to that of type 310 stainless up to 1800 F.

Physical properties — Physical properties of the new steel are given in Table 4.

Availability

Four processes are currently being used to melt Unitemp 212 in commercial-sized heats: air melt, Duomelt, Inductovac and Duovac. At the present time, sheet and bar stock are available from 2000-lb Inductovac heats. For larger billet sizes, particularly if optimum stress-rupture strength is required, it is recommended that this alloy be produced by the Duovac process.

Full scale experimental Duomelt heats are now in process in an effort to provide larger section sizes. However, it appears that the stress-rupture strength will be slightly inferior to that obtained from Inductovac and Duovac heats as a result of the higher manganese and silicon contents of the Duomelt material. This increase, however, does not ad-

TABLE 1—COMPOSITION

Carbon	0.05-0.15
Manganese	0.50 max
Silicon	0.50 max
Chromium	15.00-17.00
Nickel	23.00-27.00
Titanium	3.70-4.30
Aluminum	0.50 max
Columbium + Tantalum	0.30-0.90
Boron	0.005-0.10
Zirconium	0.02-0.09
Sulfur	0.04 max
Phosphorous	0.04 max

TABLE 2—TENSILE PROPERTIES OF UNITEMP 212

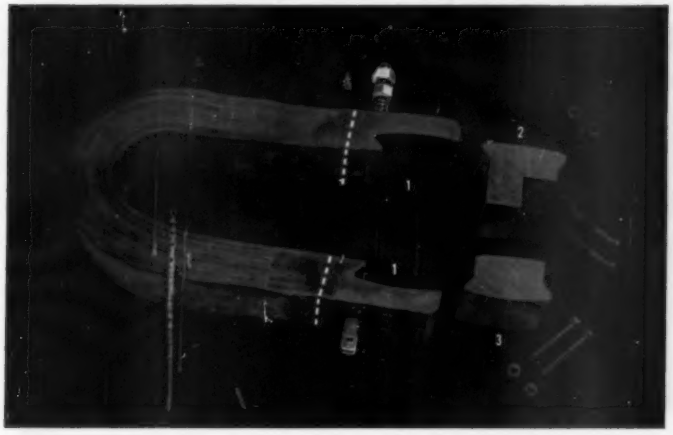
Temp →	Room	1000 F	1200 F	1400 F
TYPICAL PROPERTIES				
Yield Strength, 1000 psi				
0.02% Offset	112	112	105	85
0.2% Offset	135	127	123	103
Tensile Strength, 1000 psi	187	160	145	108
Elongation, %	20	20	15	16
Reduction of Area (bar only), %	32	32	23	25
Modulus of Elasticity, 10^6 psi	28.6	23.2	21.9	20.9
Modulus of Rigidity, 10^6 psi	10.4	8.40	7.95	7.53
Poisson's Ratio	0.306	0.328	0.336	0.346
MINIMUM PROPERTIES				
Yield Strength (0.2% offset), 1000 psi	120	116	112	90
Tensile Strength, 1000 psi	178	145	135	95
Elongation, %	10	10	8	8
Reduction of Area, %	20	20	15	15

TABLE 3—LOW TEMPERATURE PROPERTIES OF UNITEMP 212

Condition and Form →	—320 F (Condition C)[a]		—320 F (Condition D)[a]	
	⅝-In. Bar	0.075-In. Sheet	⅝-In. Bar	0.075-In. Sheet
Yield Strength (0.02% offset), 1000 psi	170	145	154	139
Tensile Strength, 1000 psi	252	241	249	246
Elongation, %	18	22	24	25
Reduction of Area, %	23	15	30	20

[a]See Table 5 for explanation of conditions.

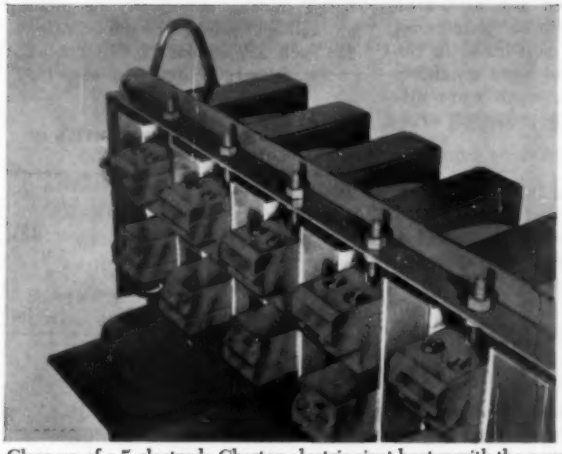
$70 COST CUT for each electrode assembly—through use of Anaconda extruded copper shapes—helped Frank C. Cheston Co. add replaceable contact feature in its line of electric rivet heaters.



Electric rivet heaters are tough, simple machines that have for years been saving time and money in riveting operations. But Frank C. Cheston Co., Newark, N. J., saw a chance to save its customers some money in maintenance, too, by making electrode-assembly contacts easy to remove for resurfacing or replacement.

Originally these contacts were integral with the laminated copper conductor forming a one-turn secondary in the step-down transformer. In redesign, only parent blocks (1, at left) are welded to the conductor. Contact shoes (2 and 3), which mate precisely with parent blocks for unimpaired conductivity, are easily removed by unbolting*.

Machining pieces 1, 2, and 3 from copper bar stock ran costs so high that the price of the heater would have become unrealistic. American Brass specialists were consulted and precisely shaped extrusions of high-conductivity copper were produced, from which the finished sections are cut. Tolerances were closer and surfaces finer than with machining—and costs per electrode assembly were cut $70.



Close-up of a 5-electrode Cheston electric rivet heater with the new removable contact feature for easier maintenance. Savings from use of Anaconda extrusions enabled Cheston to include this new feature at practically the same price as heaters of previous design.

Cheston electric rivet heater in use showing how step-design of upper contact (2, in illustration above, left) makes it easy to heat both long and short rivets. Contacts are opened by foot pedal and contact pressure is maintained by springs seen just above the pedal.

CUTTING shop costs may be easier than you think. Take a fresh look at the way you're making metal parts. Make a note of any part you suspect might benefit by the use of extrusions, special-shaped tube, die-pressed forgings, etc. Then call in your American Brass Company representative and talk it over with him. He will see that your problem gets to the right Anaconda technical specialists promptly and will expedite the answer. Or write: The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda Brass, Ltd., New Toronto, Ontario.

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versely affect the short-time tensile properties. For applications where maximum stress-rupture or creep strength is not required, air melt or Duomelt sheet can be used to advantage because it possesses higher yield strength at temperatures up to 1400 F.

Fabricability

The alloy is rolled and forged from initial temperatures of 1950-2000 F. It is more resistant to deformation than austenitic stainless steels and consequently requires more frequent heating.

According to Universal, the new alloy is not only easily welded but is less susceptible to cracking than weaker alloys of this type currently being welded by commercial practices. Tests indicate that conditions A and B are best (see Table 5).

Formability is said to be quite good, and machining is easily accomplished using techniques and equipment employed for austenitic stainless steels. Finish machining operations may be performed in the solution treated and aged condition, but are, of course, much more difficult because of the increased hardness.

Heat treatment

Unitemp 212 is a precipitation hardening alloy, and develops its best properties through solution heating and precipitation hardening. The solution treatment consists of soaking at high temperature followed by rapid cooling. A solution treatment of 1800 F is recommended since it results in the best combination of properties. Higher solution temperatures can be used to improve the rupture strength at 1350 F with some sacrifice in notch rupture properties at 1200 F. Rapid cooling from the solution treating temperature results in minimum hardness (approximately 85 Rockwell B), and this treatment may be used as a preliminary and intermediate anneal during the course of various operations such as cold drawing, rolling, forming, stamping, etc.

Maximum hardness and short-time tensile properties are obtained by aging 16 hr at 1375 F. For applications requiring optimum stress-rupture properties at 1200-1400 F, aging temperatures of 1325 F are recommended. Since heat treatment develops the high strength properties of this alloy, it is not necessary to utilize cold work or hot cold work to produce high yield strengths. However, these processes can be used to obtain higher yield strengths than are obtainable by heat treatment alone. Large sections are oil quenched from the solution temperature; thin sections, such as sheet, may be air cooled.

The five heat treatments used to obtain the mechanical properties listed in the accompanying tables, as well as specific recommendations for each, are summarized in Table 5.

(more What's New on p 126)

TABLE 4—PHYSICAL PROPERTIES OF UNITEMP 212

Density, lb/cu in.	0.286
Coef of Ther Exp (86-1500 F), 10^{-6} in./in./°F	9.83
Ther Cond, Btu/sq ft/ft/hr/°F	
212 F	7.1
1472 F	15.0
Melting Point (approx), F	2480

TABLE 5—HEAT TREATMENT OF UNITEMP 212

Condn	Treatment	Used Where . . .	Hardness, Rockwell
A	Solution treat 2 hr at 1800 F; fast air cool	Formability and weldability are required	B85-95
B	Solution treat 2 hr at 1900 F; fast air cool	Formability and weldability are required	B80-90
C	Condition A plus 16 hr at 1325 F	High temperature applications require notch and plain bar strength from 1200-1400 F	C38-43
D	Condition B plus 16 hr at 1325 F	Notch rupture strength at 1200 F can be sacrificed to increase plain bar properties at 1350 F	C36-41
E	Condition B plus 16 hr at 1375 F	Best short-time tensile properties are required from room temperature to 1400 F	C39-44

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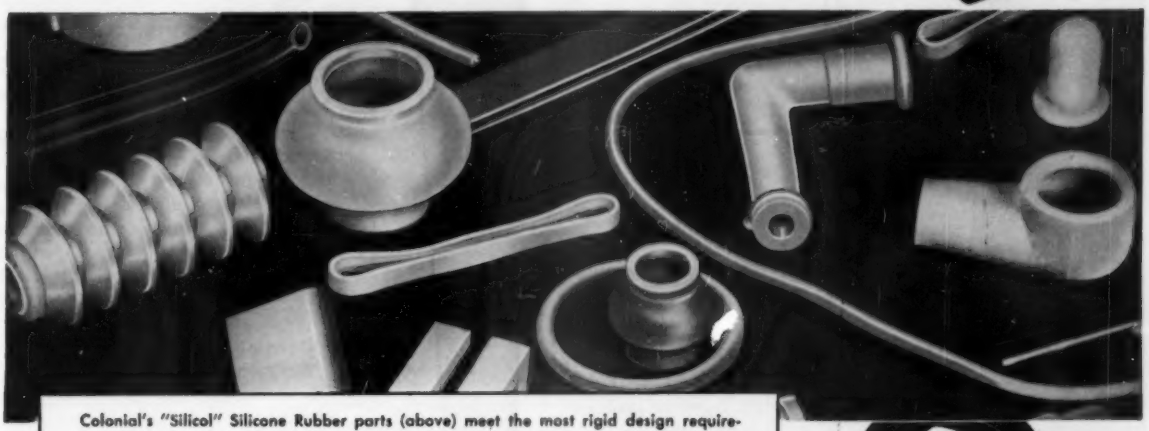

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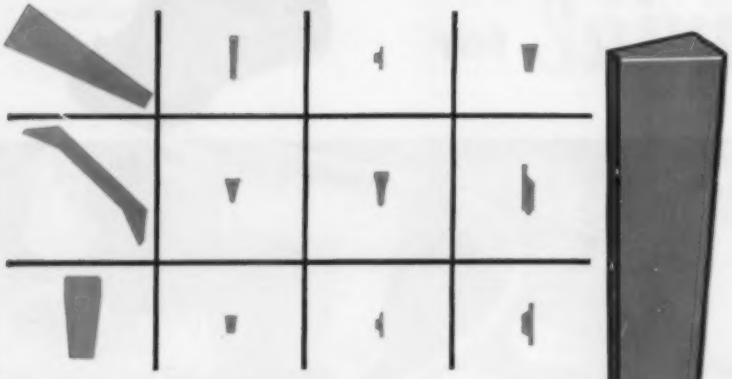

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Silicone Encapsulant for Electronic Parts

A zirconium orthosilicate-filled, solventless silicone resin appears to be suitable for encapsulating and potting electronic components and apparatus. Developed by Dow Corning Corp., Midland, Mich., the material is said to be economically competitive with other encapsulating materials.

Extensive tests by Dow Corning scientists and engineers show the encapsulant has 1) long life at 480 F, 2) good dielectric properties over a wide range of temperatures and frequencies, 3) good water, moisture and chemical resistance, 4) high thermal conductivity, and 5) excellent radiation resistance.

Potential uses

Because of its excellent thermal characteristics, the encapsulant is expected to find use in servo-motors, control devices and other equipment designed for use at temperatures of 480 F and higher. Engineers will probably find the material suitable for motors, controls and other devices used with nuclear reactors because of its excellent radiation resistance.

Although little if any difficulty is expected with this material in most commercial applications, the extreme thermal shock requirements of military specifications may limit its use in airborne and ordnance equipment.

Properties

Laboratory tests performed on capacitors encapsulated with the filled silicone resin show the material has a dielectric constant of 7.5 over a temperature range of 73 to over 570 F. Findings from other tests are summarized below:

1. *Dissipation factor* of the silicone encapsulant is approximately 0.008 at 0.1 mc.

2. *Volume resistivity* of the encapsulant is approximately 2×10^{13} ohm-cm at room temperature. Volume resistivity decreases at higher temperatures, but remains above 5×10^{10} ohm-cm at 570 F.

3. *Moisture resistance* is good, as

This article is based on a paper by J. B. Allen, R. L. Spraetz and M. E. Nelson, Dow Corning Corp., and presented at the National Conference on the Application of Electrical Insulation, Sept '58.

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Impact strength ft.-lb./in. (Izod, notch)	12.0	4.5
Flexural strength	20,000	16,000
Heat distortion	>450°F	>450°F

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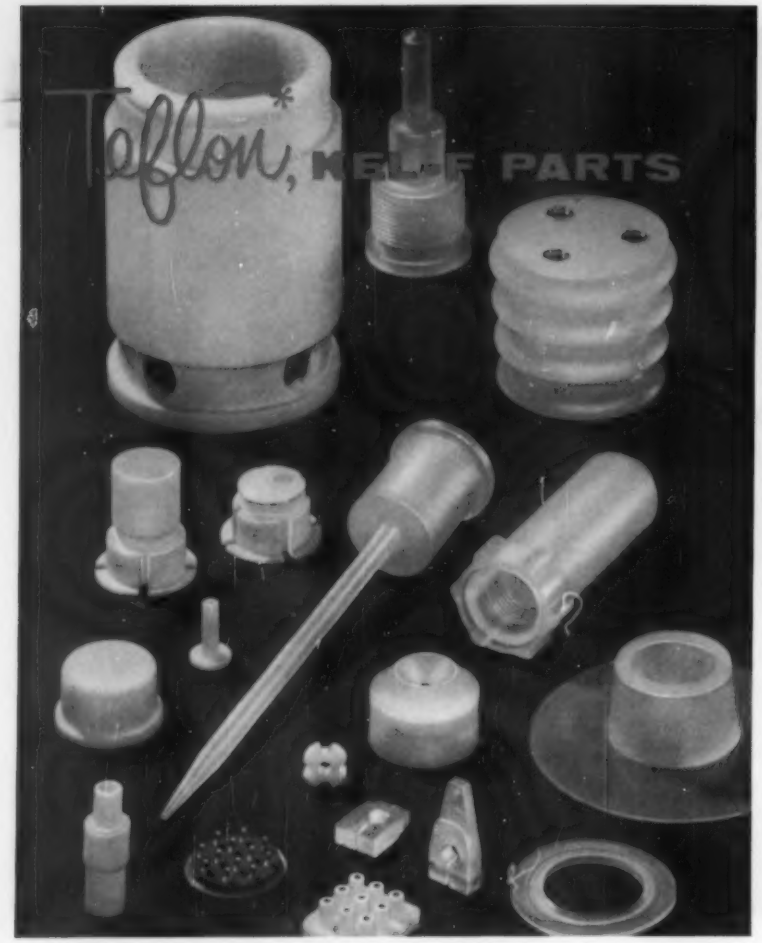

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PROPERTIES OF SILICONE ENCAPSULANT[a]

Type →	Unfilled	Filled
PHYSICAL PROPERTIES		
Moisture Abs (24 hr), %	0.03	0.03
Coef of Ther Exp, per °F	69.4	16.7
Weight Loss (200 hr at 480 F), %	5.4	1.7
MECHANICAL PROPERTIES		
Notched Izod Impact Str, ft-lb/in.	0.25	0.50
Flex Str, psi	7,600	6,000
Compr Str, psi	18,000	11,700
Barcol Hardness	10	—
Heat Dist Temp, F	122	300
ELECTRICAL PROPERTIES		
Dielec Str, v/mil	350	240
Vol Res, ohm-cm		
Dry	5×10^{13}	4×10^{15}
Wet[b]	5×10^{14}	2×10^{15}
Dielec Const (60 cps)		
Dry	2.85	7.69
Wet[b]	2.85	7.92
Dissip Factor (60 cps)		
Dry	0.002	0.008
Wet[b]	0.003	0.013
Arc Res	5	20-50

[a]Cured 16 hr at 300 F, then 3 hr at 390 F.
[b]Aged 96 hr at 96% RH and 73 F.

indicated by a small decrease in volume resistivity after high humidity exposure. Tests show that resistivity drops from 4×10^{15} to 2×10^{15} ohm-cm after 96 hr exposure to 96% RH at 73 F.

4. *Dielectric strength* at room temperature is approximately 240 v per mil when measured on a ⅛-in. thick sample; for thinner sections, dielectric strength is appreciably greater.

5. *Thermal stability* of the filled-solventless silicone resin is good. Two tests are currently being used to evaluate the material. In one test, a 1-hp, 440-v, 3-phase motor with a totally enclosed stator potted in the filled resin is being subjected to successive heat runs. At latest report, the motor had run 1650 hr at an average copper temperature of 570 F, and at intermittent temperatures as high as 1000 F for an hour or more.

In the second test, capacitors encapsulated in the material are being exposed to high temperatures. The

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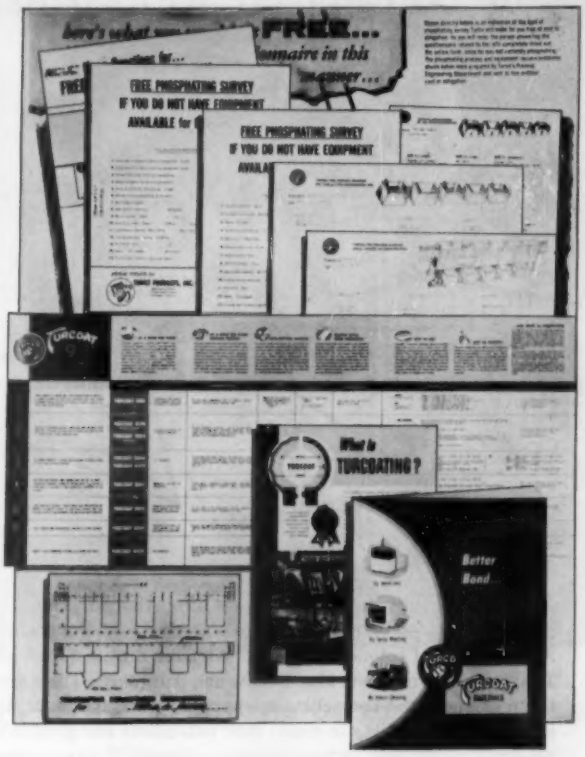

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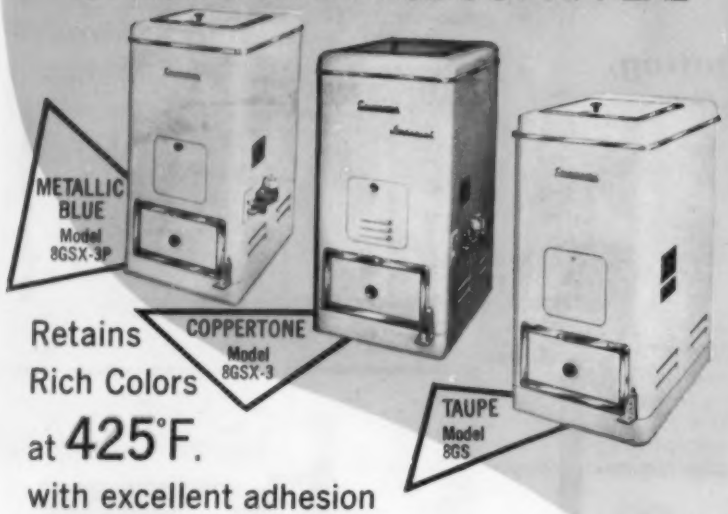

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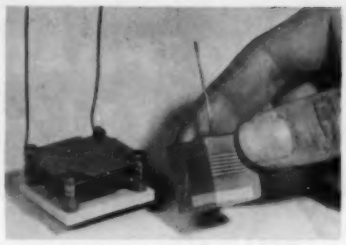
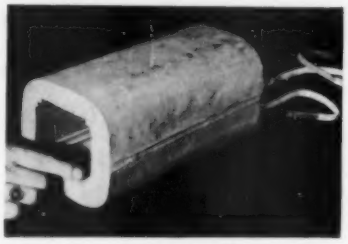


***Capacitor** as it looks after encapsulating with filled silicone resin.*



***Induction heating coil** encapsulated with filled silicone resin. Coils of this type are sometimes subjected to molten metal.*

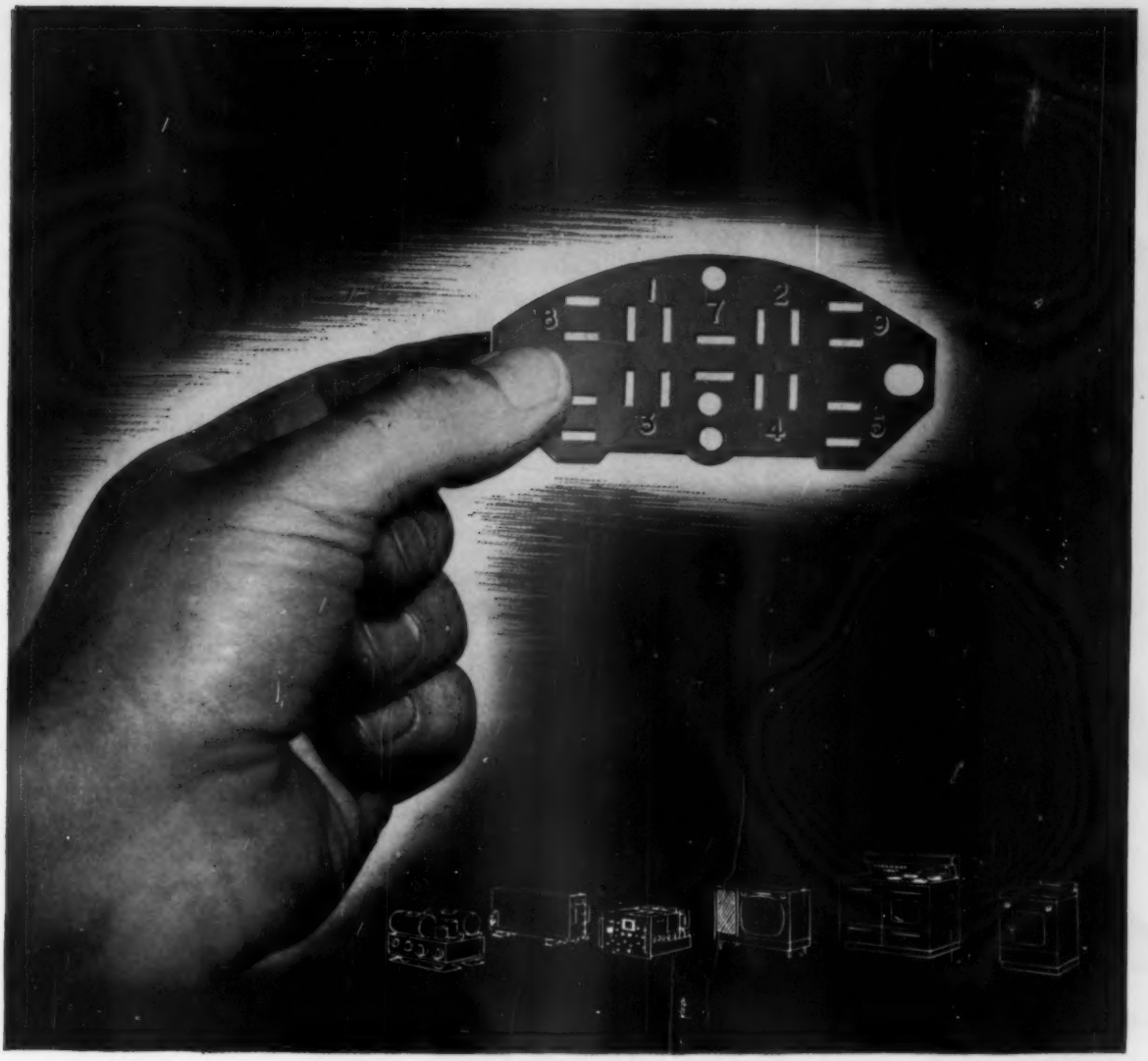
test shows that dielectric constant and dissipation factor of the material are improved somewhat by aging at 570 F. No evidence of cracking or other physical change has been observed; in addition, moisture resistance remains high.

Chromium Is Applied Directly to Aluminum

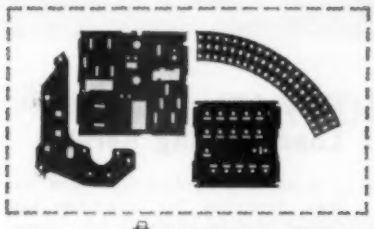
Development of a method for plating chromium directly to aluminum and its alloys has been announced by Service Hard-Chromium Co., Rte. 22, Union, N. J.

According to the company, the process applies chromium directly to the base metal with no intermediate metallic deposition of copper, nickel or zincate needed. The plating method is said to eliminate galvanic action and prevent undesirable electrolytic couples.

Called Chrom-Lume, the method deposits electroplates that are oxidation resistant, hard and ductile. In laboratory tests, severe deformations made by hammer and chisel blows showed the chromium electroplate was ductile enough to with-



LET SPAULDING GIVE YOU A HAND WITH YOUR TERMINAL BOARD PROBLEMS



Specially trained Sales Engineers . . . a broad choice of basic materials . . . extensive fabricating facilities . . . 85 years of experience. These Spaulding assets are at your disposal for terminal board material selection, design or production.

Spaulding's variety of basic materials provide unique combinations of properties to solve any problem in application. They have extremely high dielectric strength, low cold flow, good staking qualities, as well as toughness, chemical inertness, moisture resistance and dimensional stability. They are available fabricated to your exact specifications in completely uniform parts and in basic form such as sheets, rods and tubes.

Contact Spaulding. A Spaulding Sales Engineer can be at your office in a matter of hours with complete data on basic materials, fabricating service and engineering assistance.

SPAULDING FIBRE COMPANY, INC.

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For more information, turn to Reader Service card, circle No. 469

No. 3 of a Series

GRIPPING STORIES
from the files of Angier Adhesives

The Case of the BAFFLED DESIGNER

It was a tough job and "Rush", but now he had it licked. All he needed was the adhesive that would join the rubber component to the metal base. "No problem here," he thought, as he specified the rubber-to-metal formula that had been so successful in a previous job.

But there *was* a problem and it became more and more apparent as one after another of the trial bondings failed.

Once on the case, an Angier man unravelled the mystery in short order. He pointed out slight—*but important*—differences between the old product and the new—in rubber compound used, in end-product vibration and in heat and stress factors involved. He recommended an adhesive that was perfect in every respect and the designer met his deadline with two days to spare.

Turn to Angier *first* for job-tailored adhesives that are developed, tested and produced *by experts* to give you the most efficient product for every job at the lowest price per end-product unit.

Call or write today *for complete information.*

ANGIER ADHESIVES

INTERCHEMICAL CORPORATION
Finishes Division
120 Potter St., Cambridge 42, Mass.
Midwestern Plant: HUNTINGTON, IND.

For more information, turn to Reader Service card, circle No. 416

stand chipping, peeling, cracking and flaking.

The company says it is presently electroplating fasteners, gears, pinions, pumps, valves, flow control devices and pulleys.

Improved Bar Steel Needs No Heat Treating

Jalcase 100, an improved high strength, stress-stabilized, free-machining, cold finished bar steel, is now being produced by Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30. J&L says the bar steel permits significant cost savings in production of wear resistant parts by eliminating in most cases the need for heat treatment during fabrication. Other features of the improved bar steel are:

1. A guaranteed minimum yield strength of 105,000 psi for round sizes 1½ in. in dia and smaller (100,000 psi for 1½ to 3. in dia and 90,000 psi for diameters over 3 in.).

2. A guaranteed minimum hardness of 248 Bhn in round sizes up to 1½ in., and 241 Bhn for larger sizes.

3. Control of stresses that normally result in distortion after machining. Stress control is achieved by a processing technique that stabilizes and balances internal stresses in the bar steel.

The producer says Jalcase 100 is similar in chemical composition to C-1144 steel.

Polyolefin Resins for Load-Bearing Service

A series of polyolefin resins has been developed for long-time, sustained load-bearing service. Introduced by Phillips Chemical Co., Bartlesville, Okla., the resins sell for 43¢ per lb.

According to Phillips, fibers made of these resins have held loads of 20,000 psi for over 5000 hr without failure—20 times longer than fibers made from existing polyethylene resins. (For comparative information on another series of polyolefin

AS UNIFORM AS FORGINGS CAN BE

In making up an order of Bethlehem forgings, we go all out to achieve uniformity. Not just the kind that will pass visual inspection . . . but the kind that stands up under close metallurgical and dimensional inspection. The drop forgings you receive from Bethlehem have been carefully checked. That's why you will find them of uniform quality; uniformly *good.*

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service Card, circle No. 392

For more information, turn to Reader Service card, circle No. 479

PROPERTIES OF PLASTICS RESINS COMPARED

Type →	Marlex 5000[a]	Marlex 6000[a]
Density, gm/cu cm	0.950	0.960
Melt Index	0.2	0.2
Tensile Strength, psi	3800	4400
Elongation, %	70	30
Notched Izod Impact Str, ft-lb/in.	5	14
Stiffness, psi	100,000	150,000
Durometer Hardness	D68	D68
Softening Temp, F	255	260
Brittleness Temp, F	-180	-180
Environ. Stress-Cracking Res (Igepal, 122 F)[b], hr to 50% failure	150-200	60

[a]Low melt index resins.
[b]Bell Telephone Laboratories test.

resins for long-time, sustained load-bearing service, see M/DE, Oct '58, p 140.)

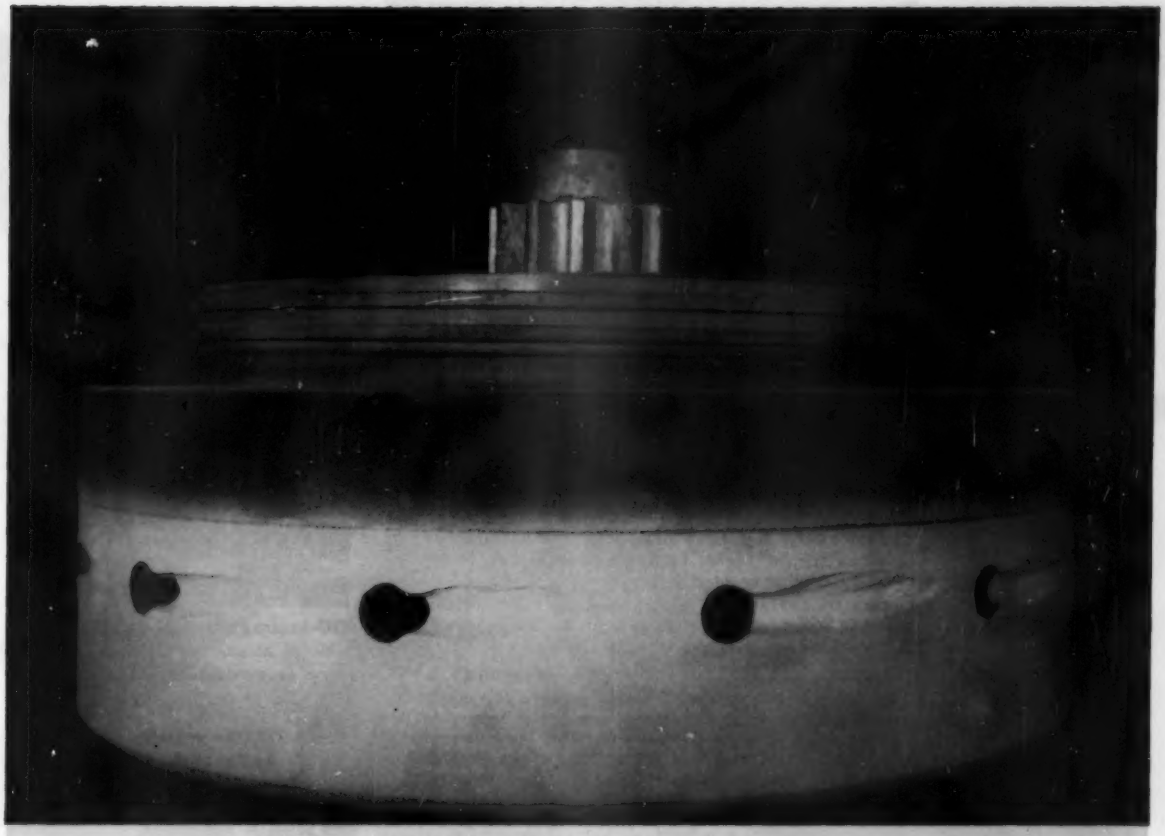
Designated Marlex 5000, the resins also show promise for use in bottles and films. Many household agents such as liquid detergents introduce severe stress-cracking problems in plastics containers. Marlex 5000 resins resist these agents even after prolonged storage at high temperatures, according to T. L. Cubbage, vice president and general manager of the company. He says other types of the polyolefin resins will find use in certain film applications such as soft goods overwraps.

The resins have been designated Marlex 5000 because they are lower in density (0.950 gm per cu cm) than the five types of Marlex 6000 (0.960) already in production.

Iron Powder Bearing Offers Cost Savings

A new oil-impregnated iron powder bearing is said to cost considerably less than bearings made from porous bronze. The reason for the saving is a 4 to 1 reduction in the cost of constituent materials.

The bearing was developed by Amplex Div., Chrysler Corp., P. O. Box 2718, Detroit 31. It is recommended for use in applications where corrosion is not a problem and mechanical strength requirements are within tolerable limits. Called Iron



The Georgia Kaolin Company, well-known manufacturer of industrial clays, reports that they have made substantial savings by coating worn separator centrifuge bowls with Norton ROKIDE "A" coating. Worn bowls were previously returned to their manufacturer after six to eight months of high speed service for restoring to their original condition. But now Georgia Kaolin applies ROKIDE "A" coating before the bowls become badly worn . . . and at a fraction of repair cost at the factory. Service life is greatly extended. Maintenance costs and down time are substantially reduced.

How ROKIDE* Coatings increase service life, cut maintenance costs of moving parts

ROKIDE coatings are applied by heating the end of a ceramic rod and projecting the molten particles at high velocity. Reaching a prepared surface, they adhere and solidify. Protecting parts of a wide variety of sizes and shapes, these coatings are in extensive, rapidly increasing use in military and general industrial applications.

Three types of ROKIDE spray coatings — "A" aluminum oxide, "ZS" zirconium silicate and "Z" zirconium oxide — are hard, adherent, crystalline refractory materials. Parts, particularly metals, on which these coatings are especially useful are those requiring thermal or electrical insulation . . . resistance to wear or corrosion . . . excellent mechanical strength . . . dimensional stability . . . relative chemical inertness.

Possible applications: bearing surfaces, metal rolls, feed rolls, nozzles, pump shafts, thermocouple tubes and wire, mechanical seals, extrusion dies, laboratory molybdenum boats, vibratory feed hoppers, metal guides, metal melting pots, sanding fixtures, induction heating coils, strain gages, and applications in the wire industry.

Norton maintains facilities for applying ROKIDE coatings at Worcester, Mass., and at its plant 2555 Lafayette Street, Santa Clara, California. For further facts, write to NORTON COMPANY, New Products Department, 700 New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

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NEW PRODUCTS

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more information, turn to Reader Service card, circle No. 477

look at these advantages of

IRIDITE FINISHES

for

CORROSION-RESISTANCE, PAINT BASE on ALUMINUM and MAGNESIUM

EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

OUTSTANDING PERFORMANCE—Forms a film that is an integral part of the metal itself. Can't flake, chip or peel. Takes paint firmly on initial application, and the bond lasts. Even protects areas scratched in use.

LOWEST COST—You have only minimum equipment cost, no special racks, high speed operation, lower overall handling costs.

CHOICE OF APPEARANCE—Clear coatings that retain metallic lustre to dark, maximum protection coatings. A variety of colors is available by dyeing.

IRIDITE #14 and #14-2 (Al-Coat) for ALUMINUM

Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection.

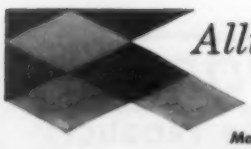
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE #15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

APPROVED UNDER GOVERNMENT AND INDUSTRIAL SPECIFICATIONS

SEE FOR YOURSELF WHAT IRIDITE CAN DO . . . SEND SAMPLE PARTS FOR FREE PROCESSING. Look at the results, test the protection, evaluate the savings. Also write for handy Reference File of the most complete data published on chromate conversion coatings. Or, for immediate information, call your Allied Field Engineer. He's listed under "Plating Supplies" in your classified phone book.



Allied Research Products, Inc.

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***Manufacturers of* IRIDITE®, IRILAC™, ARP® Brighteners and Plating Chemicals — West Coast Licensee: L. H. Butcher Co.**

For more information, turn to Reader Service card, circle No. 362

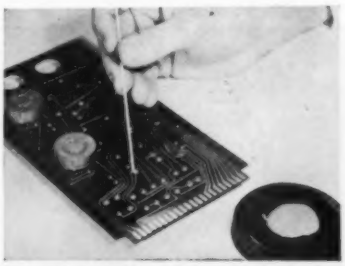
What's new IN MATERIALS

***Oil-impregnated bearing** is available in sleeve, flange and spherical form in production quantities.*

Oilite 212, the bearing has potential use in home appliances, fractional horsepower motors, power tools, light machinery, instruments and communication equipment.

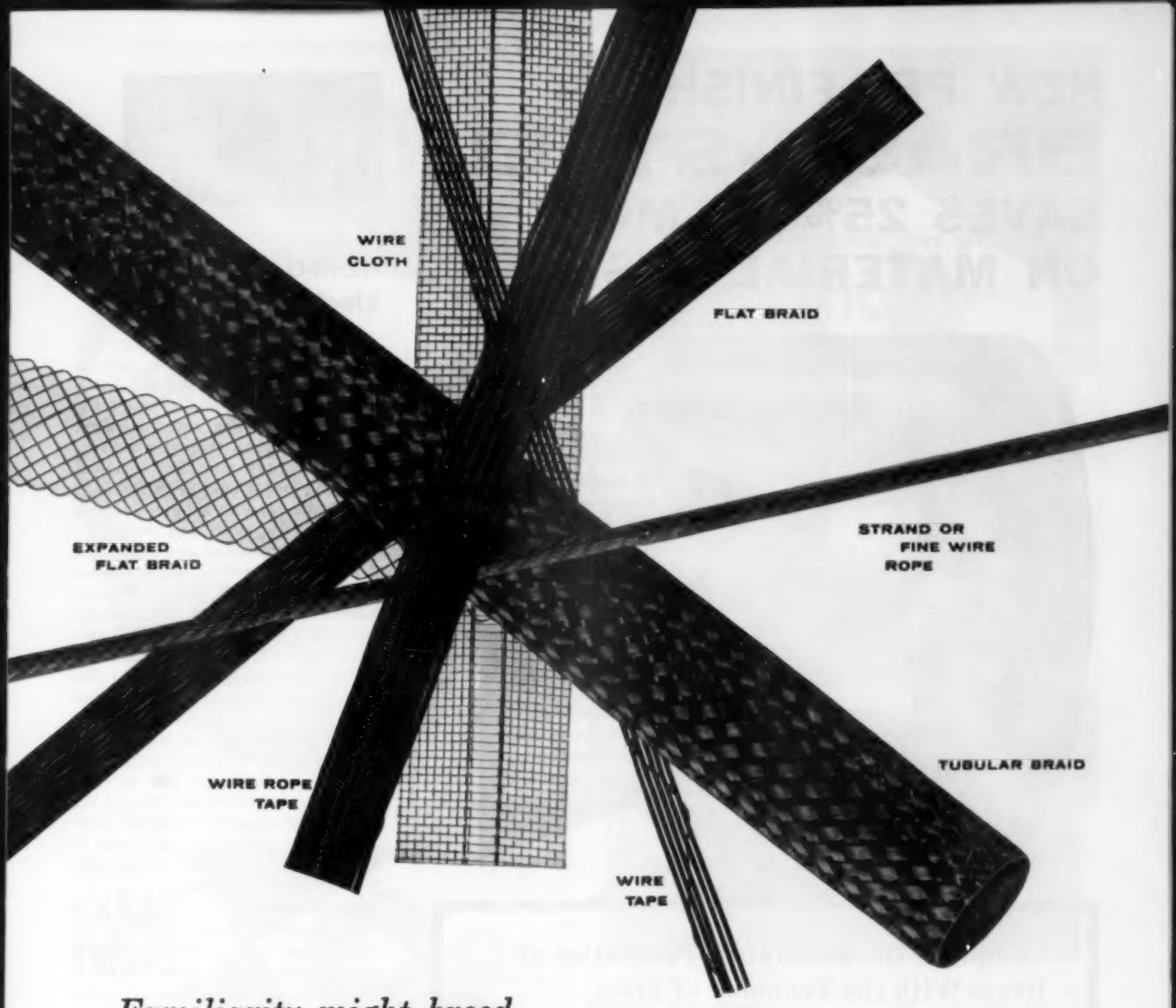
According to Amplex, the high oil content of the bearing (approximately 20% by volume) makes it self-lubricating for the lifetime of many products. The bearing is said to give optimum service when carrying a medium to heavy load at relatively low speeds.

(more What's New on p 138)



Conductive epoxy adhesive—The epoxy adhesive being applied to the printed circuit above was developed especially for repairing printed circuits and for bonding electrical parts where soldering cannot be tolerated. The conductive adhesive is 100% solids and has a volume resistivity of 0.01 ohm-cm. Called Hysol 6250, the adhesive is available from Houghton Laboratories Inc., Olean, N. Y.

For more information, circle No. 433 ➤



Familiarity might breed

NEW PRODUCT IDEAS!

The wire fabrications shown here, highly developed specialties of National-Standard, are available in many types and sizes. Each can be produced in any metal that can be drawn into wire.

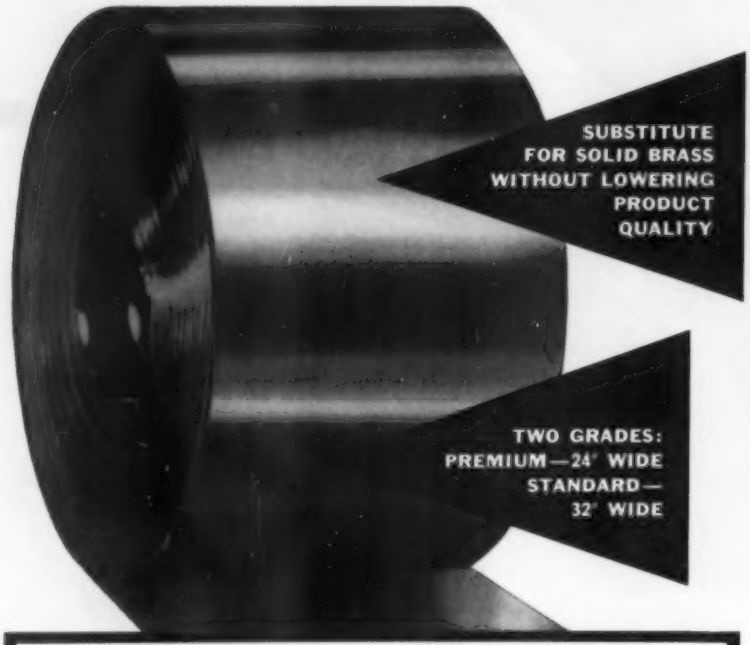
These materials are used in numerous products today for many different reasons . . . for strengthening, stiffening, protection, safety, decoration, filtering, screening, heat or electrical conductivity, grounding, etc., etc.

Can one of these materials meet a present or new product requirement of yours? You'll never find an organization more cooperative or better qualified to help you fully explore any such ideas. Just get in touch with National-Standard, Niles, Michigan.

NATIONAL STANDARD

NATIONAL-STANDARD, Niles, Mich.; *tire wire, stainless, music spring and plated wires, flat and tubular braid and wire cord*
WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires, high and low carbon specialties* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels*
CROSS PERFORATED METALS, Carbondale, Pa.; *industrial, commercial, and decorative perforated metals*

NEW PRE-FINISHED BRASS-STEEL SAVES 25% OR MORE ON MATERIAL COSTS



Combines the Decorative Properties of Brass With the Economy of Steel

Where the only BRASS you *need* is the brass you *see*, save 25 percent or more on material costs, reduce production steps with brass-plated steel. This way, the only BRASS you pay for is the substantial brass coating you *really need*. Big 32" wide coils — the widest ever made — in Standard grade, for utility or decorative uses; 24" wide in Premium grade, our finest quality — an economical substitute for pure brass for many applications. Both grades are sealed with BAKEKOTE, a baked resin film. Mar-Not protective coating protects the pre-finished surface during fabrication. Big 24" and 32" wide coils and sheets — bright and satin finishes and crimps. Also stripes in sheets, only.

UNPOLISHED — For those parts designed beyond the fabrication limits of our regular pre-finished material, consider *unpolished* Brass-Steel. Excellent for post-finishing work or for applications where high surface finish is not required.

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NICKELOID METALS SINCE 1898 N·M

AMERICAN NICKELOID COMPANY
PERU 6, ILLINOIS

Mills: Peru, Ill. and Walnutport, Pa. — Sales Offices Throughout the U.S.A.

For more information, turn to Reader Service card, circle No. 372

Hand-Operated Gun for Electrostatic Painting

Electrostatic spray painting, now a production line process, can be done with a newly developed hand-operated gun. In many cases, the gun has a painting rate equivalent to or better than that of a conventional air-spray gun. For instance, the hand gun is said to be considerably faster than an air gun in spray painting rods, tubes and wires.

The hand-operated gun, called No. 2 Electro-Spray Process, was developed by Ransburg Electro-Coating Corp., 3939 W. 56th St., Indianapolis 23, Ind. (For information on Ransburg's automatic units, see MATERIALS & METHODS, Oct '51, p 146.) The developer says almost any metal part and many nonmetallic parts can be painted with the electrostatic hand gun. It is ideally suited for exterior surfaces and can be used for some interior areas. Except for a few materials of relatively high electrical conductivity, all types of industrial coatings can be used successfully with the gun.

How it works

Electrostatic spray painting attracts paint to a part as iron filings are attracted to a magnet. Parts to be coated are grounded electrically by conveyor hangers or other supports. A voltage pack connected to the gun with a flexible cable creates an electrostatic field between an atomizer on the end of the gun and the part to be coated. Coating material is supplied to the atomizer by a pressure tank or pump unit; rotation of the atomizer feeds the paint uniformly. Paint is atomized by the electrostatic field, producing a spray pattern of electrically charged particles. Electrostatic attraction pulls

***Painting a water heater** with a hand-operated electrostatic gun.*

For more information, turn to Reader Service card, circle No. 379

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MOLD-RESISTANT
PAPER,

MOSINEE

will make it to your
EXACT SPECIFICATIONS

for complete information write
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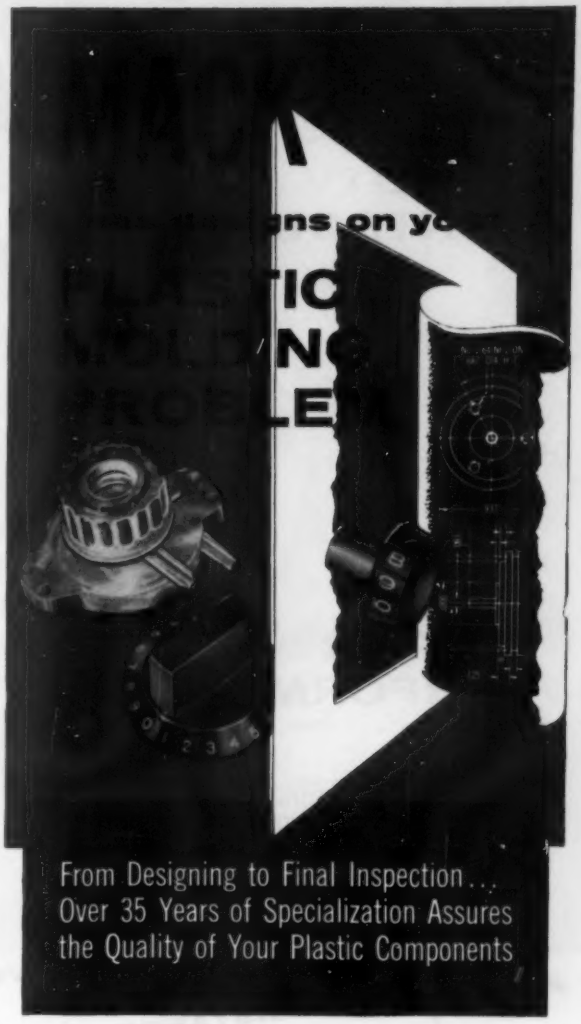

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Over 35 Years of Specialization Assures
the Quality of Your Plastic Components

*KARAK TWINS?
...NOT ON YOUR LIFE!

Between two shaft seals alone, KARAK properties yielded these widely divergent characteristics

Seal Requirements	A	B
Mating surface	Hastalloy C	Stainless Steel
Carbon surface	Hard, Polished	Low Friction Film
Pressure at seal	75 PSI	15 PSI
Speed at seal face	5,400 RPM	4,500 RPM
Material under control	HF	Ethylene Glycol
Indicated life of seal	1,200 HRS	1,000 HRS
KARAK grade number	A	B

Multiply these differences by hundreds of design applications... That's KARAK! We have, or will make a grade to meet your specs.

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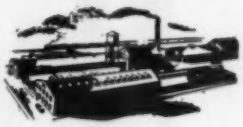
Includes the facilities of three completely equipped plants. Mack design and production engineers are familiar with the problems involved in molding intricate precision industrial parts and functional components for consumer products.

From Blueprint to Delivery

Mack will work with you from the planning stage right through to final delivery. For assistance on specific requirements, just call or write: Mack Molding Company, Inc., Wayne, New Jersey.

Serving Industry for Over 35 Years

Three plants to help with your plastic problems:



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Experimental Vacuum Melting Furnace

Chemical Laboratory

Better Performance – on every electrical and electronic application because... from ingot to final inspection, every test known to science safeguards the quality of Wilbur B. Driver Precision Alloys. These tests assure performance as specified! Why not consult a Wilbur B. Driver sales engineer for recommendations on precision alloys for your applications.

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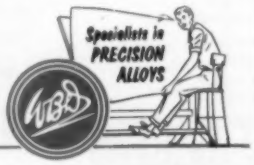


IN CANADA: Canadian Wilbur B. Driver Co., Ltd.
85 King Street East, Toronto 1

For more information, turn to Reader Service card, circle No. 365

the paint spray to the part, and essentially all of the spray is deposited on the part.

TFE-Coated Foil Has Good Thermal Stability

TFE-coated copper, stainless steel and aluminum foils are being turned out by a new bonding process in which TFE is integrally bonded to the metal foil. The resulting material is said to have excellent thermal stability, with metal and TFE coating reacting as one to temperature changes.

The coated foils, products of Materials Research Corp., 47 Buena Vista Ave., Yonkers, N. Y., are expected to find use in miniature capacitors and transformers.

Tests show that the coated metal foils can be used continuously at temperatures up to 570 F. Other tests show that the new TFE-coated copper foil has 0.25 pinholes per sq ft compared to the conventionally coated TFE-coated copper foil which has as many as 22 pinholes per sq ft.

According to the producer, the coating process turns out foils coated on one or both sides with coating thicknesses varying from 0.001 to 0.002 in.

Safe, Fast Method for Cleaning, Painting

A safe, fast and economical method for cleaning and painting metal parts was announced recently by E. I. du Pont de Nemours & Co., Inc., Electrochemicals Dept., Wilmington 98, Del.

The method is said to sharply reduce initial investment costs, operating costs and floor space require-

Correction

The article "Conductive Silver Ink for Printed Circuitry" in the Oct '58 issue, p 174, line 51, is incorrect. Motson is not selling silver inks; rather it performs the service of printing tubes with silver inks to meet customer specifications.

DESIGNED IN CELANESE FORTIFLEX...

LINT SCREEN FOR GAS AND ELECTRIC DRYERS

MOLDED IN CELANESE FORTIFLEX BY THE GENERAL INDUSTRIES COMPANY, INC., ELYRIA, OHIO

Maytag Lint Screen has new toughness, heat-resistance . . . in Fortiflex

When Maytag required a material for the lint screen in their new gas and electric dryers, they sought one that would give them new rigidity and toughness, more heat-resistance . . . and they found it in Fortiflex. The high temperature-resistance of this high-density, linear polyolefin plastic extends to sterilization levels. Fortiflex is five times more rigid than conventional polyethylenes, and it has the necessary smooth, lustrous surface to handle laundry gently.

Fortiflex "A" is presently available in four melt indexes developed to accommodate a wide range of conditions and applications of interest to designers and manufacturers. For more information and/or test quantities, just use the handy coupon.

Celanese® Fortiflex®

TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-300
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	—200	—180	—160	—100
Impact Strength, Izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	$N^{23}D$	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	130,000
Water Absorption (⅛" specimen, 24 hrs. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

*Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Fortiflex...a Celanese plastic

Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N. Y. 16

For more information, turn to Reader Service Card, circle No. 459

Celanese Corporation of America, Plastics Division,
Dept. 102-A, 744 Broad Street, Newark 2, N. J.

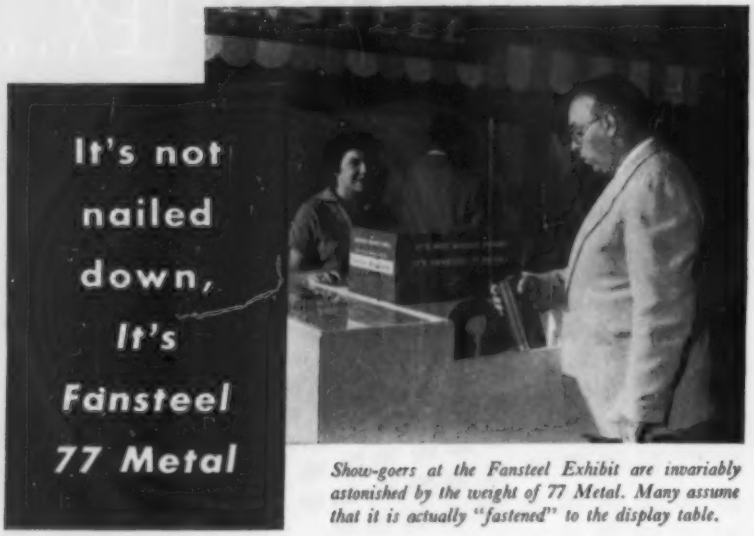
Please send: ☐ more information on, ☐ test quantities of Fortiflex.

Name_____ Title_____

Company_____

Address_____

City_____ State_____



Show-goers at the Fansteel Exhibit are invariably astonished by the weight of 77 Metal. Many assume that it is actually "fastened" to the display table.

Fansteel 77 Metal's startling weight provides the solution to many engineering problems . . . especially those concerning inertia or momentum, counter balancing, vibration control and shielding. Its use is recommended whenever the objective is . . .

Maximum Density in Limited Space

HOW HEAVY? *Twice* as heavy as steel, *50%* heavier than lead. (.613 lbs. per cubic inch.)

HOW STRONG? Tensile strengths to 140,000 psi. Transverse rupture to 270,000 psi. Elongation to 10%.

HOW EASILY MACHINED? Machines like cast iron . . . takes fine finishes, close tolerances.

HOW ECONOMICAL? Made by powder metallurgy of pure tungsten, copper and nickel, waste of materials is limited, machining costs are cut.

Fansteel 77 Metal Is The Ideal Material For Use In . . . *Aircraft aileron counterweights, Rotors, Governors, Balance Weights of all types, Radiation Shielding, Vibration Damping Devices.*

Write for this free booklet

K565A

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U. S. A.

For more information, turn to Reader Service card, circle No. 481

ments by combining cleaning, painting and drying operations in a single machine. In the machine, all operations are carried out beneath a protective "blanket" of noninflammable trichlorethylene solvent. Present machinery is designed for automated flow painting, but can be adapted easily for dip painting.

Tests at Du Pont indicate that noninflammable trichlorethylene-thinned paints can be formulated with properties similar to those of most conventional paints. In general, any paint ingredient that is soluble in trichlorethylene, such as certain alkyd resins, epoxy esters, acrylic resins, asphaltic materials and chlorinated rubbers can be used in compounding trichlorethylene-thinned paints. The paints can be pigmented, and may be decorative as well as protective in nature.

Reinforced Plastics Contain Up to 70 % Glass

Glass-reinforced plastics parts with glass contents up to 70% by weight can be obtained by using a new series of plastics compounds. The molding materials are glass yarns (not rovings) coated with various thermosetting resins. Potential uses for the compounds, called Trevarno, are missile and rocket parts, electrical parts and thermal insulations.

Seven types available

Developed by Coast Mfg. & Supply Co., P. O. Box 71, Livermore, Calif., the molding compounds are supplied in seven types:

F92: A general purpose phenolic compound with good mechanical properties at temperatures up to 400 F.

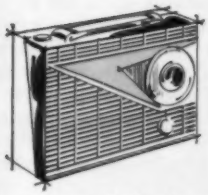
F120: A heat resistant phenolic compound that can be used continuously at 500 F and intermittently at 5000 F.

F121: A phenolic compound with better heat and erosion resistance than F120.

F130: A silicone compound that has good long-time mechanical properties at temperatures up to 500 F.

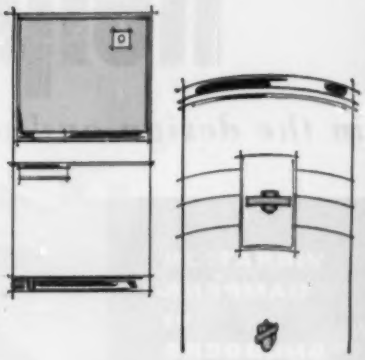
F141: A heat and flame resistant polyester compound that has good electrical and mechanical properties

NOW! To Your Specifications



- Distinctive Product Nameplates and Labels
- Decorative Panels
- Beautiful Metalized Trim

...Die cut, Embossed, Screened Printed or in Rolls, Strips, Sheets

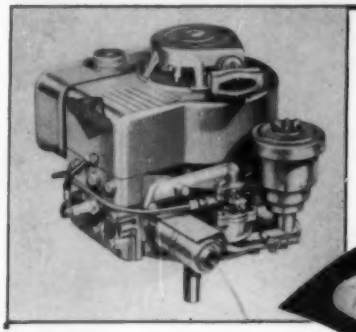


Our specialization in this wondrous — fantastic — field of decorative self-adhesive materials offers many advantages to you. Our "know-how" shortcuts the way to development of a self-adhesive application most suited to your needs. In short, we can supply you with a *better looking* product *faster* for less!

Investigate now! Learn how Avery can simplify your production and cost problems with new Decorative Products.

FREE BROCHURE AVAILABLE — Contains samples, describes uses! Write Dept. M-1.

Avery Adhesive Label Corp.
Decorative Products Division
2123 East 9th Street, Cleveland 15, Ohio



NO MOLD COST!

Reduced Unit Cost

on your initial run will effect savings for you that could very easily cover the cost of mold.

That is actually being done on many jobs similar to the starter pulley bumper (shown above) that SINKO molded for use on the Briggs and Stratton engine illustrated. Dupont ZYTEL was the plastic used because of its ability to resist wear, its quiet operation, and self-lubricating qualities.

Call on us when you're in need of Plastic Molded Parts . . . we'll produce them for you, accurately, speedily, and economically!

WE MOLD ALL THERMOPLASTICS—2 TO 175 OZ.

Sinko MANUFACTURING and TOOL CO.
7310 W. WILSON AVE • CHICAGO 31, ILL.

Offices in Principal Cities Throughout the United States

For more information, turn to Reader Service Card, circle No. 382

A NEW PRODUCT IS PLANNED...

...and you have an idea that *one special* extruded aluminum shape can be used instead of *several standard* rolled sections of another metal, saving many manufacturing steps and money. The idea needs exploring . . . the opinion of experts. But, the budget for research of this type is slightly battered. The matter is no longer a problem, for G.E.I.'s highly skilled staff is eager and ready to discuss your idea with you, *at no obligation*, on one part or a million. G.E.I. engineers specialize in adapting extruded aluminum to new functional roles . . . and they can soon tell you whether your idea is fact or fancy.

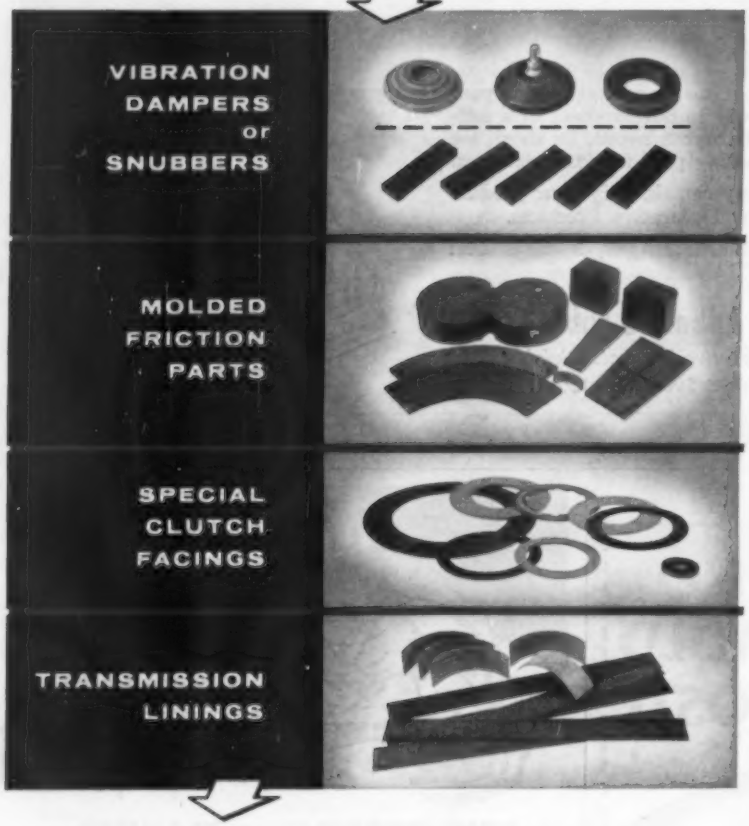
GENERAL EXTRUSIONS, INC.
4040 LAKE PARK RD., YOUNGSTOWN, OHIO
Mill Representatives at St. Louis, Detroit, Memphis and Cincinnati
Consult your classified phone book under Aluminum Products.

For more information, turn to Reader Service Card, circle No. 377

let **WORLD BESTOS**

help you

in the design and production of



● World Bestos offers you more than 30 years' engineering and manufacturing experience in the producion of molded friction parts. Chances are our immense resources and facilities can supply you with molded parts and friction components—to meet your requirements—at a savings in both time and money.

Send your blueprints (or samples) for prices and delivery information to WORLD BESTOS, Industrial Products Section, New Castle, Ind., Phone: JAckson 9-4790
Write for free illustrated folder.

WORLD BESTOS NEW CASTLE, INDIANA

DIVISION OF THE Firestone TIRE & RUBBER COMPANY

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

For more information, turn to Reader Service card, circle No. 440

at temperatures up to 350 F.

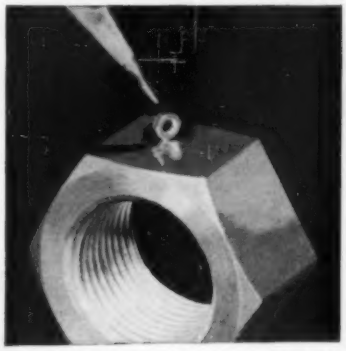
F148: A general purpose polyester compound that has good electrical properties at temperatures up to 250 F. The compound is also said to have good flow characteristics.

F160: A heat resistant epoxy compound that has good mechanical properties at temperatures up to 500 F.

Painted Metal Strip Can Be Drawn, Bent

Painted metal strip that can be deep drawn, stamped, bent, blanked, roll formed and die formed without fracture is available from Brainard Steel Div., Sharon Steel Corp., Warren, Ohio.

Present and potential applications include automotive stampings, still and motion picture film containers,



Tiny precision brass nut—The tiny brass nut shown above is said to be identical in type and accuracy to the large nut beside it. The tiny nut, measuring ⅛ by 3/64 in. and weighing 0.11 lb per thousand, is tapped square with faces to Class II tolerances, countersunk on both sides, deburred and degreased.

The producer, Fischer Special Mfg. Co., 508 Morgan Ave., Cincinnati 6, Ohio, says the tiny nut was developed to solve fastening and assembly problems in miniaturized electrical and electronic equipment, such as transistorized radio and television sets, business machines, fractional and flea horsepower motors, and printed circuitry. The nut is supplied in single or double chamfered styles.

For more information, circle No. 493 ➤

There is no substitute for stainless steel
in automobiles

No other material is as bright, strong and resistant to rust and wear as Stainless Steel. It gives every car the clean, exciting beauty that sells in the showroom and re-sells on the used car lot. Look for *Stainless Steel* on your new automobile.

Specify McLouth high quality sheet and strip Stainless Steel. McLouth Steel Corporation, Detroit 17, Michigan.

McLOUTH STAINLESS STEEL

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....Gray Iron Castings	....Designing Metal Stampings
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sanding equipment, baseboard heating panels, tubing, door and window frames, novelties, toys, drapery and curtain rods, seals and bottle caps.

Coatings are applied by a continuous process in which metal strip (0.008 to 0.065 in. thick and 12 in. wide) is run through painting and baking units. Materials presently being coated include black plate, cold rolled strip, sheet coil, electrogalvanized sheet and Sharon Galvanite.

The coated strip is available in all colors including black, white and various gold and bronze shades, and is supplied in high gloss, semi-gloss and dull finishes. The producer says color can be applied to one or two sides; painted edges can also be furnished.

Zippered Cable Jacket Withstands 3000 F

An easily applied cable jacketing that will withstand 2000 F continuously and 3000 F intermittently has been developed by Zippertubing Co., 752 S. San Pedro St., Los Angeles 14. Called Thermazip, the jacketing is made of an aluminized, reflective asbestos fiber. The jacketing is closed by a plastics or metal zipper track stitched to the fiber with TFE thread.

Used as a protective cover over cables, hoses and other parts, the jacketing is said to prevent damage to cables exposed to heat from missiles and rockets. Thermazip is available in diameters from ⅜ in. up, in increments of ⅛ in.

Lead-Free Enamel Bonds to Aluminum

A completely lead-free porcelain enamel for aluminum has been announced by American Lava Corp., Cherokee Blvd. & Manufacturers Rd., Chattanooga 5, Tenn. Strips of coated aluminum have been twisted as many as three times around without flaking off the enamel coating.

The porcelain enamel is currently used in coating aluminum architectural panels, cooking ware and advertising signs. Uses under consideration include protective and deco-

Don't throw away those epoxy-coated rejects

Here's a new paint stripper that will save them

Do you scrap perfect metal parts that have been imperfectly coated with epoxies, vinyls, polyesters and other hard-to-strip paints or lacquers?

In the last few months, users of Oakite Stripper S-A have eliminated many such losses. Here's what some of them say about it:

CALIFORNIA: An aircraft manufacturer tested many strippers on an epoxy designed to resist attack by hydraulic fluid. Finally found that Oakite Stripper S-A is "the only one that safely strips this paint from anodized aluminum."

NEW YORK: A camera maker coats flash bulb reflectors with black vinyl paint outside and aluminum paint inside. "Stripper S-A is the fastest ever used on our rejects."

OHIO: A maker of toy pistols had trouble stripping alternate coats of lacquer and metallized aluminum. Now "Stripper S-A does it amazingly fast and remetallizing is completely satisfactory."

CALIFORNIA: A producer of metal furniture uses Stripper S-A to remove clear epoxy from plated parts. Chemist says "This is the best stripper on the market."

ALABAMA: A hardware maker had trouble stripping lacquer from brass door knobs. Oakite Stripper S-A now does the work in "less than ⅓ the time taken by any other stripper."

NEW YORK: A manufacturer of business machines tested several strippers on various finishes on steel and aluminum. Verdict in favor of Stripper S-A was: "It's doing a wonderful job."

CONNECTICUT: A maker of brass lipstick shells has found that "Stripper S-A quickly strips epoxy lacquers from rejects and heavily coated work spindles."

CALIFORNIA: A missile maker reports that "Stripper S-A is doing a fine job stripping vinyl from stainless steel and titanium."

FREE Write Oakite Products, Inc., 40 Rector St., New York 6, N. Y., for complete information on Oakite Stripper S-A.

In our 50th year.

OAKITE

Technical Service Representatives in Principal Cities of U. S. and Canada

Export Division Cable Address: Oakite

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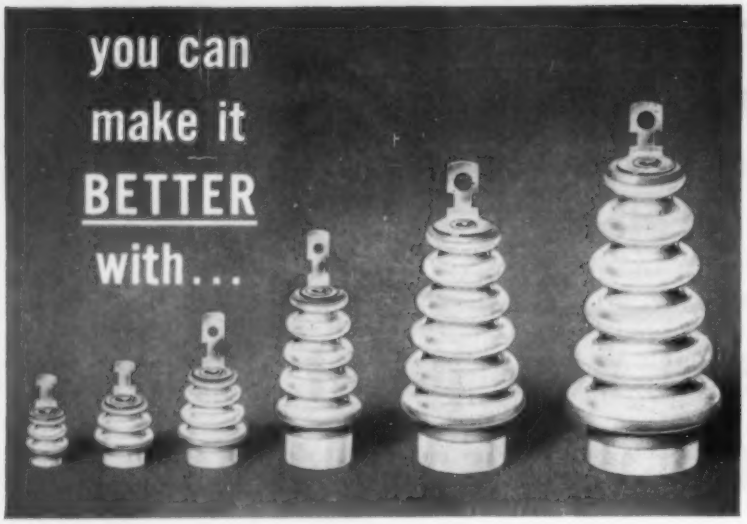


...NICOTE® Metallized Hermetic Terminals

Whenever your plans call for the use of terminals in controls, relays, transformers, capacitors, motors, or heater units, take a tip from satisfied engineers everywhere and investigate the plus-values of NICOTE Metallized Hermetic Terminals.

Custom-engineered of HIGH ALUMINA CERAMICS and metallized with Frenchtown's exclusive NICOTE, these terminals offer you definite advantages:

- Will withstand continuous immersion in lead-tin solder at 260° C. (500° F.).
- Reduce tracking through superior external shape, so important in smaller size terminals.
- Provide easier threading of wire through the terminal because of improved *tapered* bore design.
- Effect a permanent, positive seal that is resistant to high thermal and mechanical shock.

NICOTE Metallized Hermetic Terminals are available in six varying sizes with a choice of terminal hardware to fit any exacting application.

Write today for Engineering Data Sheet 1055 which provides complete terminal specifications plus engineering details on a wide selection of terminal hardware.

frenchtown PORCELAIN COMPANY
FRENCHTOWN, NEW JERSEY

For more information, turn to Reader Service Card, circle No. 375

***Coated aluminum** can be sheared, drilled, cut and punched with little or no chipping of the enamel.*

rative coatings for aluminum boats, awnings, outdoor furniture, sanitary ware and other items. The enamel can be applied to most wrought aluminum alloys, as well as castings and extrusions, provided they can withstand firing temperatures of 950 to 1000 F.

Barrier Material

A barrier material made of heat sealable polyester film which has been vacuum metallized and bonded to a backing of scrim has been announced by Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. The material, called Scotchpak barrier material, meets Mil Spec MIL-B-131C, Class I.

According to 3M, the material has excellent resistance to delamination by preservative oils, greases and volatile corrosion inhibitors when subjected to extreme changes of environment during handling and storage. Standard roll size of the material is 36 in. × 200 yd.

Aluminum Alloy 5083 Sold in Coils, Sheets

Aluminum alloy 5083, a high strength, non-heat treatable material, is now available as sheet from Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11. Formerly, the material was available only as plate.

The aluminum alloy sheet is expected to find use in processing equipment, marine truck trailers, highway guard rails and construction equipment. According to the producer, the sheet has weldability

KANIGEN COATING

protects Hamer "VISIBLE WEDGE" Line Blinds

For positive shut-off in piping systems, engineers have long relied on Hamer Line Blind Valves. These absolute sealing valves provide substantial savings in time and product loss which often repay the cost of the valve in a surprisingly short period of time. When Hamer developed its series of Visible Wedge line blinds, an effective protection of the wedge surfaces against corrosion was desired. After thorough test and study, Kanigen nickel-alloy coating was selected for these surfaces. "Application of the Kanigen coating process," say the men at Hamer, "provides us with an effective corrosion barrier of this vital part, and greatly increases the service life of the valve."

KANIGEN nickel alloy, chemically deposited as a hard, uniform coating, provides corrosion resistance and protection from product contamination wherever nickel is needed. Less costly than alloys, solid metals or clad materials, it can be used in a wide range of equipment—from small valves to the interior of huge tanks and dryers.

Equipment and parts can be jig-coated, rack-coated or barrel-coated at GENERAL AMERICAN plants at East Chicago, Indiana; Sharon, Pennsylvania, and Compton, California.

KANIGEN *is a trademark which identifies chemical nickel coating by GENERAL AMERICAN TRANSPORTATION CORPORATION and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coatings.*

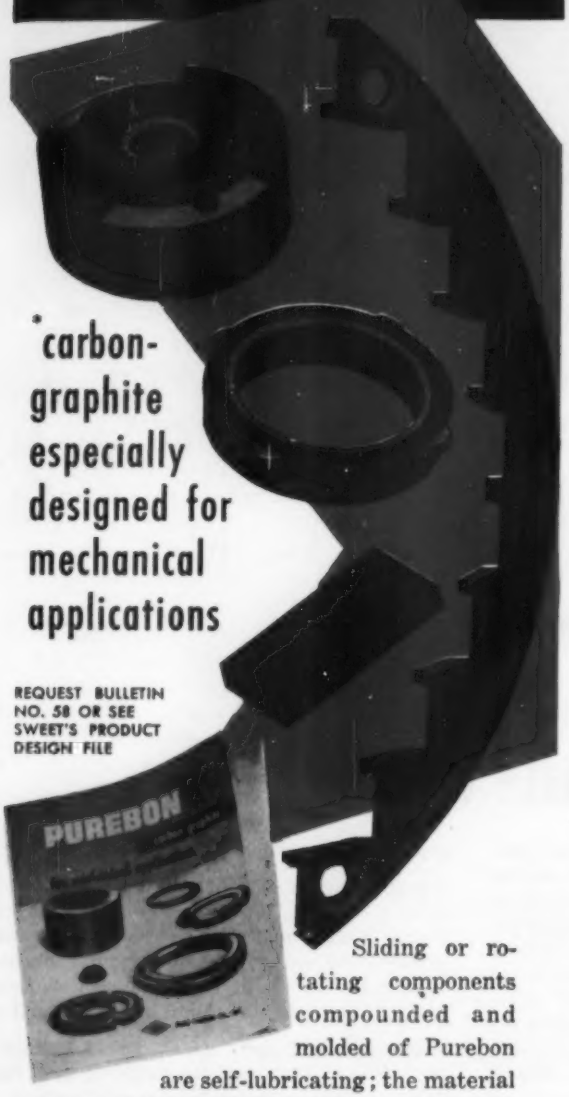
KANIGEN DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street • Chicago 90, Illinois

KANIGEN GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 487

*PUREBON

SELF LUBRICATING
LOW FRICTION
STABLE AT HIGH TEMPERATURES



*carbon-graphite especially designed for mechanical applications

REQUEST BULLETIN NO. 58 OR SEE SWEET'S PRODUCT DESIGN FILE

Sliding or rotating components compounded and molded of Purebon are self-lubricating; the material is unusually stable at high temperatures. It is readily machinable, chemically inert, light weight, low cost when moldable to size. Send prints or parts for prompt quotation.

PURE CARBON CO., INC.
447 HALL AVE., ST. MARYS, PA.

For more information, turn to Reader Service card, circle No. 506

PROPERTIES OF 5083 SHEET

Temper →	O	H32	H34
Ult Ten Str, 1000 psi	45	49	53
Yld Str, 1000 psi	23	39	43
Elong, %	23	10	8

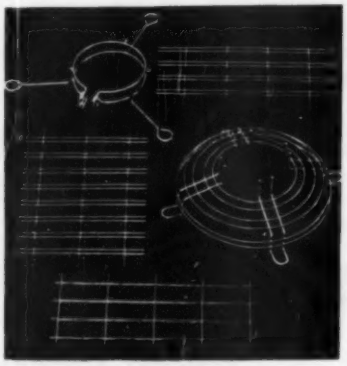
comparable to that of 5083 plate (approved by ASME for welded unfired pressure vessels).

The aluminum alloy sheet is available in O, H32 and H34 tempers. The alloy is supplied as flat sheets in widths up to 60 in. and in thicknesses from 0.50 to 0.249 in. It is also supplied as coiled sheets in thicknesses from 0.050 to 0.125 in.

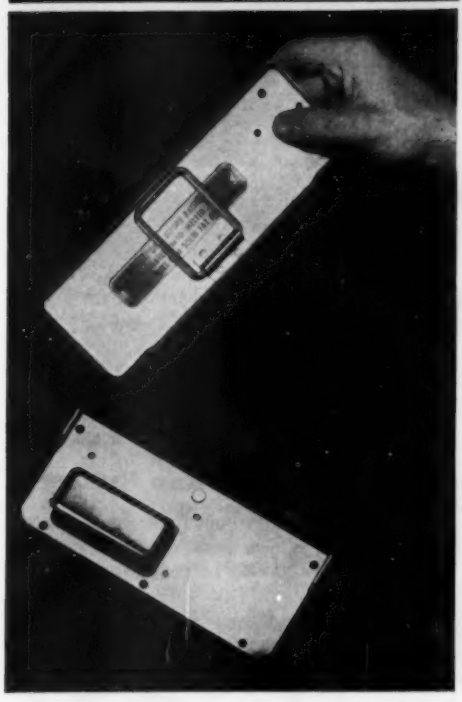
Coated Wire Parts Available in Colors

Zinc chromate-coated wire parts and welded wire assemblies are now available in a number of colors from E. H. Titchener & Co., 67 Clinton St., Binghamton, N. Y. Color-coated wire, Titchener says, should be of particular interest to manufacturers in the radio, television and appliance fields where fan guards, wire motor mounts, decorative grilles and other wire parts must be designed with emphasis on attractive product appearance. The color-coated wire parts are also said to offer an economical means of providing color identification in assembly operations.

(more What's New on p 152)



***Wire products** such as the motor mounts, fan guards and grilles shown here are now available in color.*



SAVED: $2.50 A UNIT

With 4 Heat-Resisting Parts of Armco ALUMINIZED STEEL

Looking for a low-cost metal to "handle" high heat?

Read what Mr. J. Jarmuth, Plant Superintendent, Wells Manufacturing Company, San Francisco, says about Armco ALUMINIZED STEEL Type 1 and cost savings in commercial frying units:

"Every item in our Counter-Mate line contains ALUMINIZED STEEL. Its advantages in high-heat applications are obvious, but we have been able to obtain equally important benefits from the cost standpoint.

"Neither plated nor baked enamel parts on concealed or semi-concealed details of our units have been completely satisfactory. Both have been far more expensive than ALUMINIZED STEEL.

"For example, on our F-77 double fryer we have improved the durability of the product by switching to ALUMINIZED STEEL for control box backs and bottoms, shell bases, and outlet boxes. At the same time, we have effected a net saving of $2.50 a unit and have eliminated the coordination problem with local plating shops.

"As we become more and more familiar with fabricating techniques in forming, drawing, and spot-welding ALUMINIZED STEEL, we are expanding our use and are confident that it is a major factor in the successful quest for a better product at lower cost."

Perhaps Armco ALUMINIZED STEEL is a low-cost answer for heat-resisting parts of your product. Fill in and mail coupon for complete information.

New steels are born at Armco

ARMCO STEEL CORPORATION
7018 Curtis Street, Middletown, Ohio

Send me more data about Armco ALUMINIZED STEEL Type 1

We make_____

Name_____ Title_____

Firm_____

Street_____

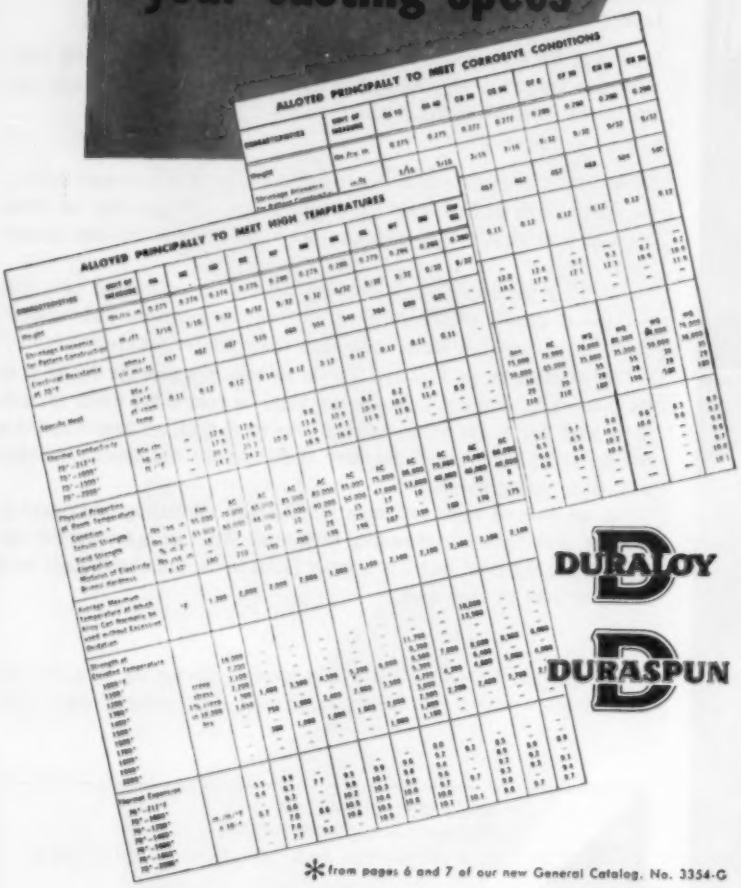
City_____ Zone____ State_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

For more information, turn to Reader Service card, circle No. 400

TABLES
to help you select the proper alloy for your casting specs



DURALOY

DURASPUN

*from pages 6 and 7 of our new General Catalog. No. 3354-G

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

The DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.

EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service Card, circle No. 391

What's new IN MATERIALS

Preplanning Properties of Urethane Foams

A technique whereby the properties of urethane foams can be planned while they are still in the liquid chemical stage was described by Raymond E. Bolin of Mobay Chemical Co. before the 1958 ACS annual meeting in Chicago.

The technique consists of measuring the distance between crosslinks in the molecular chains which make up the polymers. Polymers with longer distances between each crosslink will produce foam that is soft and elastic; polymers with shorter crosslink distances will produce foam that is stiff and rigid.

Bolin says the technique makes it possible to preplan the softer foams for cushioning, pillow and mattress applications.

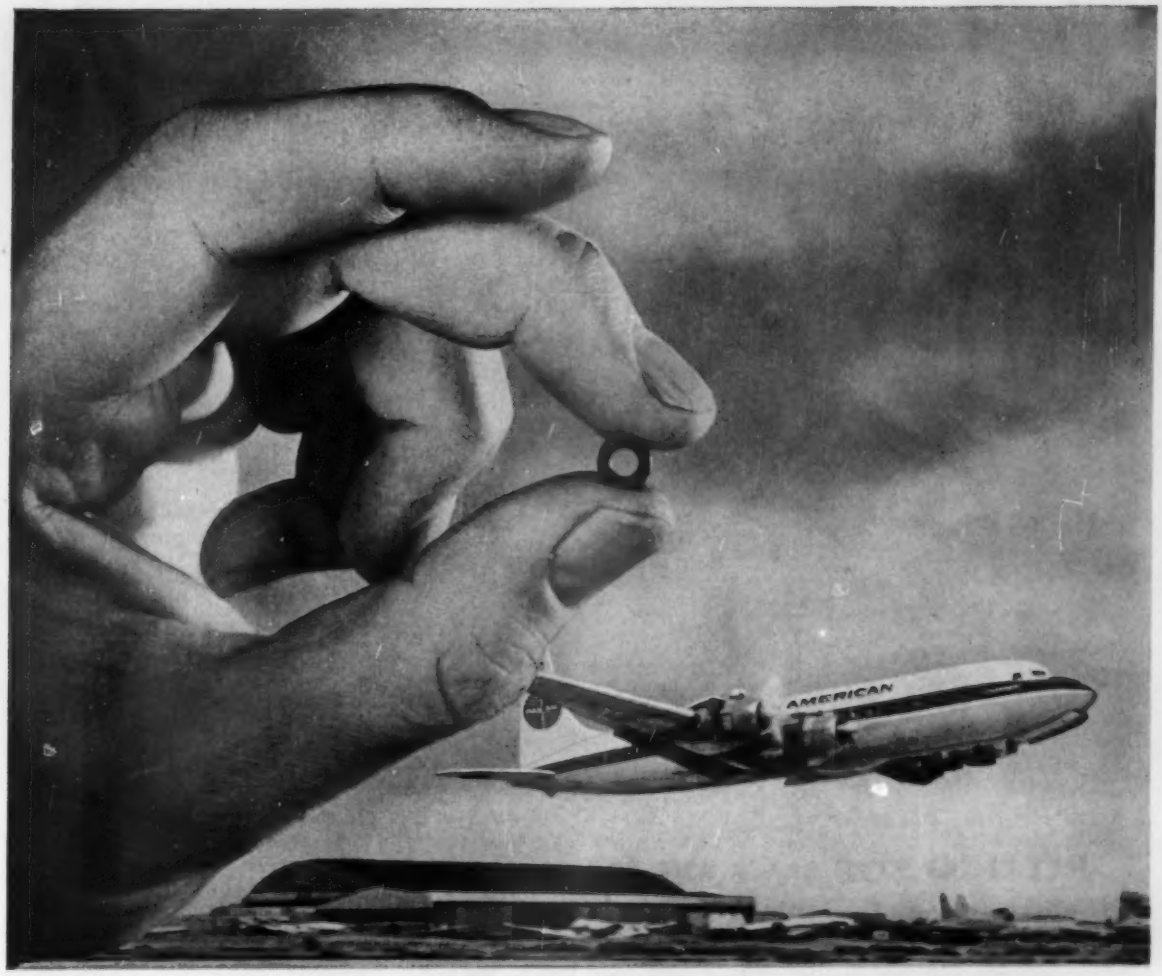
Intermetallics Available

Commercial quantities of indium antimonide, indium arsenide, indium phosphide, gallium arsenide, lead telluride, bismuth telluride, and semiconductor grades of the constituent materials indium, antimony, arsenic, lead, bismuth and tellurium are now available from Ohio Semiconductors, Inc., 1035 W. 3rd Ave., Columbus 8, Ohio.

Seals, Gaskets, Sheets Made of Viton Rubber

Viton, Du Pont's new fluoro-elastomer, is now being used in packings, seals, gaskets, sheets, o-rings and

***Typical parts** made of Viton rubber.*



How ounces of rubber harness herds of horses

Keeping the herds of horses harnessed in today's aircraft engines "on the go" often depends upon a few ounces of rubber. In the form of "O"-rings, frequently no bigger than a pencil eraser, this rubber serves as a packing on actuating cylinders, selector valves and other vital parts where positive sealing is essential.

Once, "O"-ring failures were all too frequent. Ordinary rubber could not withstand the various hydraulic fluids, the—40°F. to 160°F. temperatures, the flexing, the stretching, the elongation. But the picture changed when Goodyear introduced CHEMIGUM – first of the truly oil-resistant rubbers.

The unique composition of CHEMIGUM soon made possible "O"-rings with an absolute minimum of swell or shrinkage, excellent resistance to heat and cold, very low compression set and maximum squeeze combined with minimum friction. And its easy processing permitted meeting tolerances in the very low thousandths of an inch.

Perhaps the fate of your product also can be assured a success by CHEMIGUM. For full details, including the latest *Tech Book Bulletins*, plus the finest in technical service, just write to Goodyear, Chemical Division, Dept. A-9437, Akron 16, Ohio.

GOODYEAR

CHEMICAL DIVISION

CHEMIGUM • PLIOFLEX • PLIOLITE • PLIOVIC • WING-CHEMICALS

Chemigum, Pliolite, Pliovic—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

For more information, turn to Reader Service Card, circle No. 385

GENERAL PURPOSE PHENOLICS

gp

PLENCO 308 BLACK AND BROWN

AVAILABLE IN **STANDARD** AND **AUTOMATIC**
MOLDING PRESS GRANULATIONS

A versatile and dependable molding compound, Plenco 308 is excellent for a wide variety of general purpose molding applications. Plenco 308 is also noted for its wide preheat latitude, excellent finish and dimensional stability.

Many molders standardize on this compound because they have found that several flows, 90 and 120, for example, bracket their requirements nicely, and their inventory control problems are minimized accordingly.

As you know, flash sticking on vents can mean lost time and added expense. Recently we have improved the mold and flash release of Plenco 308 to the delight of press operators and users of automatic presses. Like them you, too, may find this compound the answer to your own needs.

IF PHENOLICS CAN DO IT—

plenco

CAN PROVIDE IT

already-made or specially-made

PLENCO PHENOLICS
FOR BETTER PLASTIC PRODUCTS

PLASTICS ENGINEERING COMPANY

Sheboygan, Wisconsin

Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

For more information, turn to Reader Service card, circle No. 504

molded and extruded shapes by Garlock Packing Co., 429 Main St., Palmyra, N. Y. (For information on the properties and uses of Viton, see M/DE, July '57, p 96 and May '58, pp 12 and 166.)

Garlock has developed basic formulations of Viton with durometer hardnesses ranging from 60 to 90. The formulations are: 9663 (60 durometer); 9466 (70 durometer); and 7592 (80 durometer). Style 7623 is an off-white formulation for use in the food industry; all other styles are black.

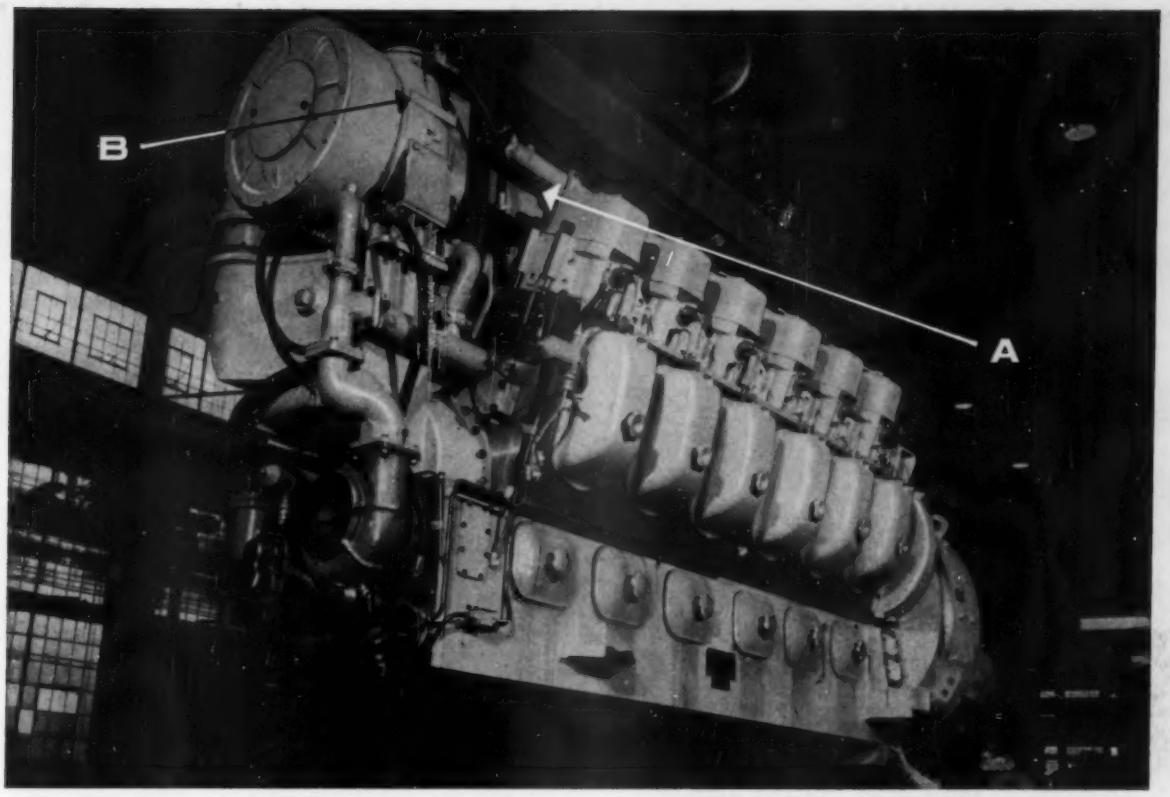
Sprayable Epoxy Resin Requires No Solvent

A sprayable, high solids, solvent-free epoxy coating has been developed that is said to eliminate the need for multicoat applications, thus permitting substantial savings in labor costs. With properly designed spray equipment, the material can be applied in a single coat up to 10 mils thick on a vertical surface without sagging. The coating, described as an amine-cured material, does not bubble even in very thick films because volatile components are absent.

Announced by Shell Chemical Corp., Chemical Sales Div., 50 W. 50th St., New York 20, the coating is currently being evaluated in the company's Technical Service Laboratory. The solvent-free coating is expected to find use as a lining material for storage tanks and process vessels. A typical formulation cures in 3 to 4 hr at room temperature and can be handled after overnight cure.

Impregnated Paper Has Good Wet Strength

A nylon-impregnated paper has been developed by Knowlton Brothers, Inc., Watertown, N. Y. for applications requiring good wet strength and high abrasion resistance. The paper, known as Grade 538, is said to maintain good abrasion resistance in both wet and dry applications. Twenty revolutions of a 10 CS wheel on a Taber Abraser make no impression on either the



To withstand wear, high temperatures and corrosion in power ring grooves, exhaust manifold, and turbocharger, new 1800 hp diesel relies on three Ni-Resist high nickel alloy cast irons. Engine is Model 251, Alco Products, Inc.

Designers go to higher operating temperatures with a lift from Ni-Resist cast irons

. . . get resistance to warping and heat, strength at high temperatures, and compatible expansion.

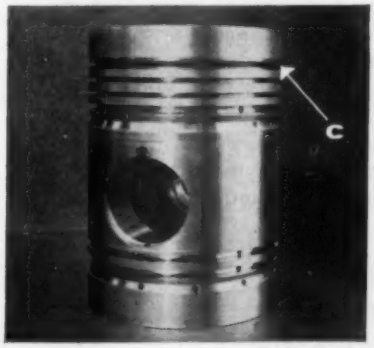
Designers of this new 1800 hp diesel wanted maximum horsepower packed in an engine of minimum fuel consumption, size, and weight.

That meant turbocharging – with resulting higher operating temperatures. For certain critical parts, they needed alloys with outstanding resistance to heat, oxidation, and scaling. At the same time, these alloys had to have expansion properties comparable with the surrounding metals.

Three Ni-Resist* cast irons used

Type 3 Ni-Resist iron was selected for the exhaust manifolds (A above). It resists scaling and warpage at manifold temperatures. In addition, its low coefficient of expansion prevents undue thermal stresses at the joints with other metals.

Type D-3 Ni-Resist ductile iron used for the turbocharger casing (B above) gives still greater strength and toughness at exhaust temperatures.



Type 1 Ni-Resist iron gives power ring grooves (C below) in aluminum pistons strength and heat resistance . . . keeps them from pounding out of shape. It also has a high coefficient of expansion that closely matches that of the aluminum piston at the high operating temperature.

When you need strong, corrosion-resisting metals that resist oxidation, warping, scaling . . . when you need specific expansion properties... investigate Ni-Resist cast irons.

You can start a Ni-Resist data file very easily. Write for "Engineering Properties and Applications of Ni-Resist" and "Engineering Properties of Ni-Resist Ductile Irons."

*Registered trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

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McDANEL

CERAMICS

may be your ANSWER

If your project has heat, abrasion, corrosion, chemical or other deteriorating factors present, then McDANEL specially-developed ceramics could be the answer. Instrument manufacturers, scientists, physicists, research and development engineers, and specialized producers are applying McDanel ceramics to a wide variety of difficult applications with good success. McDANEL ceramic engineers work with you to develop designs, special dies, even new processes to suit your particular need. Try ceramics.

McDANEL Industrial CERAMICS — 1958-OUR 40th ANNIVERSARY

McDANEL REFRACTORY PORCELAIN COMPANY
BEAVER FALLS · PENNSYLVANIA

Let us study a sketch of your application. Your inquiry is special to us.

For more information, turn to Reader Service card, circle No. 452

dry paper or paper soaked in water for 24 hr at room temperature.

The paper has a tensile strength of 58 psi crosswise and 88 psi lengthwise before pressing, and 92 psi crosswise and 118 psi lengthwise after pressing. Pressed paper has a water permeability of 12 cm, whereas unpressed paper has a water permeability of 21 cm.

Knowlton's impregnated paper is available in widths up to 60 in.

Needed: More Heat Resistant Materials

Operating temperatures for aircraft and missile materials in the next 10-year period will reach 2500 F for a few minutes and 4000 F for a few seconds, according to a survey made by the Aircraft Industries Assn.

The AIA says metallic and nonmetallic materials should be developed during the next 10 years to withstand high temperatures, nuclear radiation and erosion.

Some materials goals specified by the AIA are:

Metals: Beryllium, molybdenum, columbium, chromium, vanadium and tantalum alloys to withstand 4000 F.

Adhesives: Organic and inorganic adhesives that have a shear strength of 2000 psi after aging 600 hr at 1200 F.

Rubber: Elastomeric materials to withstand 1500 F; tires to withstand 600 F and nuclear radiation.

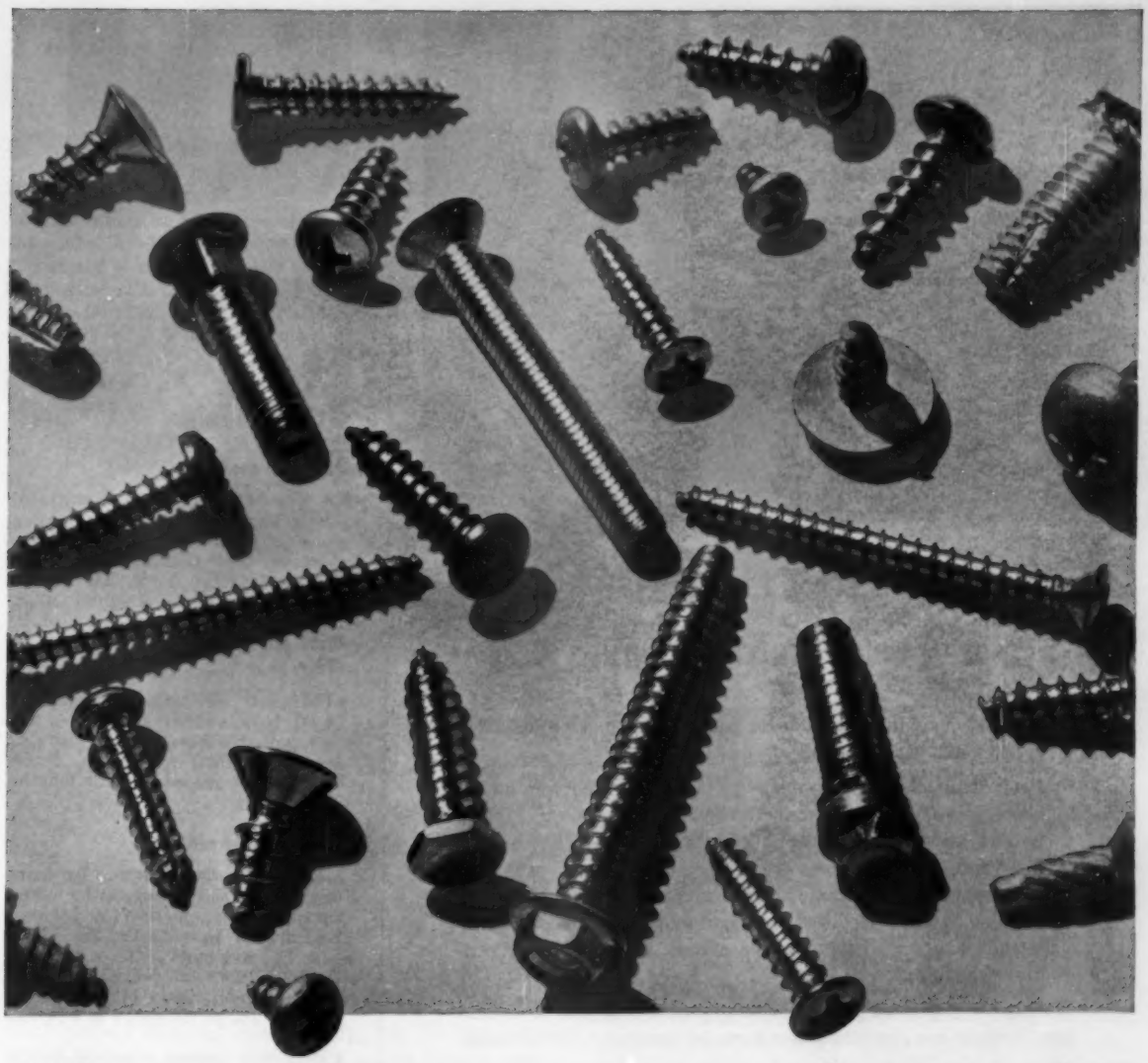
Insulations: Ceramic thermal, electrical and acoustical insulations to withstand 1500 to 3000 F.

Sealants: Noncorrosive and noncombustible materials as sealants for fuel tanks, fire walls and pressurized compartments to withstand 1000 to 1500 F.

Coatings: Flame-plated and fused ceramic and metallic coatings to withstand abrasion and erosion at temperatures up to 2000 F.

Oils, greases, fluids: Hydraulic

AWARDS COMPETITION—Be sure to get your entry in by Feb 2. For details on M/DE's third annual Awards Competition, see p 114.



Why we make so many types of screw wire

Bethlehem makes many different types of screw wire to suit each of the major groups of screws—wood, machine and tapping (sheet-metal)—which face different job requirements. And each of the many types of heads—round, flat, recessed, filister, etc.—poses different manufacturing problems.

Thus the ideal wire for a given type of fastener will differ in some way from wire made for other kinds of screws. Producing the right kind of screw wire for each specific requirement is a Bethlehem specialty. Some of this wire must have good machining properties. Some must readily respond to heat-treatment—or withstand severe cold-heading.

All of these requirements mean close control of such factors as chemical composition, heat-treatment and mechanical properties, which determine how we'll process your wire in our modern wire mills. Thorough inspection at every stage of production is but one phase of the quality-control standing behind every ton we ship.

Bethlehem makes just about every kind of steel wire. Some are general purpose grades; others like screw wire, are custom-made for a specific application. In all cases you can count on Bethlehem quality and cooperation. We invite you to consult us. Just phone the nearest Bethlehem office, or drop us a line at the address below.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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Time for a New Look at Powder Metallurgy . . .

. . . and at the additional products you can now make by powder metallurgy and save money.

Mallory Steelmet* . . . a completely different and better powder metallurgy product that, for the first time, offers strength, ductility and density comparable to wrought steel. By having Mallory produce your parts from Steelmet, you can save real money through the elimination of difficult machining and finishing operations. Mallory facilities are adaptable to a wide variety of sizes and shapes . . . have ample capacity to meet your production schedules.

Mallory's experienced powder metallurgists will be glad to discuss how Steelmet can give you better parts for lower cost. Write today.

*trade mark

Compare a Typical Steelmet With Wrought Steel*	Annealed Wrought Stainless 302	As sintered Steelmet 302
Ultimate tensile, psi	80-100,000	75-90,000
Yield strength, psi	30-45,000	35-37,000
% elongation, in 1 inch	64-45	15-30
Izod Impact, ft. lbs.	110-75	22
Density	8.0	7.4-7.6

* Send for complete information on all Mallory Steelmet products.

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

For more information, turn to Reader Service Card, circle No. 484

What's new IN MATERIALS

fluids to withstand nuclear radiation and temperatures from –100 to 600 F; oils and greases to withstand 1000 F; dry lubricants to withstand 1500 F; and vapor phase lubricants to withstand 2000 F.

Other News . . .

Ferrous metals

▸ A line of stainless steel, sintered, porous wire cloth and porous wire mesh disk-type filter elements is now available from Bendix Filter Div., Bendix Aviation Corp., 434 W. 12 Mile Rd., Madison Heights, Mich. The filter elements are supplied in eight pore sizes ranging from 5 to 250 μ.

▸ Corrosion resistant wrought iron (4-D) bars, rounds and angles are now available from A. M. Byers Co., Joseph Smith Clark Bldg., Pittsburgh. Bars are available in lengths up to 30 ft.

Nonferrous metals

▸ Solid and tubular bronze bars are produced in 105-in. lengths by a continuous casting method at Johnson Bronze Co., New Castle, Pa. Solid bars are available in 21 sizes from ½ in. to 3 in. in dia, and tubular bars are available in 118 sizes from ½ in. to 2½ in. i.d. and 1 to 3 in. o.d.

▸ Beryllium copper seamless tubing is now available from Uniform Tubes, Inc., Collegeville, Pa. The company is supplying the tubing in sizes from 0.10 to 0.625 in. o.d., with wall thicknesses ranging from 0.042 to 0.001 in. in the smaller sizes.

▸ Nickel silver, phosphor bronze and brass strips in thicknesses down to 0.001 in. are now commercially available from Seymour Mfg. Co., 21 Franklin St., Seymour, Conn.

Plastics and rubber

▸ Injection molded unplasticized PVC fittings and flanges are now available for large (6-in.) unplasticized vinyl piping. The supplier is Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.

▸ A new medium nitrile rubber named Chemigum N600 mixes readily with other compound ingredients, saves mixing time and is completely stable at normal processing temperatures. Tests run with typical stocks

for your Metals "Supermarkets"

Yes! It's Official! We've shortened our name.

Our customers are really responsible for the change. For years now, they've been calling us "Whitehead Metals," neatly dropping the last two words of our official name. It's easier to say, and much more descriptive of our activities. We agreed with them and so have made the change legal and official. From now on, we'll be known to all as Whitehead Metals, Inc.

While our name may be different, our customers and friends can rest assured our traditionally high standards of service will remain unchanged. We are still intensely interested in your metals problem. We want you to choose the *one right kind* of material for your application. Our trained engineering staff is ready to work with you and advise you. Since we stock *all* the principal corrosion resistant alloys, we can and do give you unbiased opinions.

20,000 different items are stocked in eight conveniently located warehouses for you to choose from. You'll find it will pay you to consult with your nearest Whitehead representative. We'll be happy to serve you—under our new name.

ALUMINUM • BRASS • BRONZE • CLAD METALS • COPPER • MONEL • NICKEL
INCONEL • PRIMARY NICKEL & FERRO ALLOYS • PLASTICS • STAINLESS STEEL

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For more information, turn to Reader Service Card, circle No. 465

• POLYCARBONATE
• POLYPROPYLENE
• RIGID POLYVINYL CHLORIDE

New MATERIALS IN PLASTIC EXTRUSIONS

If you are planning to use any of the newest materials, Anchor can help you. Anchor is already experienced in working with these recently developed plastics and is fully equipped to extrude sample runs for you. Should you want to try out your ideas in extruded shapes, tubes, rods or strips, Anchor's Design Engineers will be pleased to show you how to get a quality product . . . inexpensively.

ANCHOR PLASTICS
CO., INC.
36-36 36th Street
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RAvenswood 9-1494

For more information, circle No. 403

What's new IN MATERIALS

showed scorch time much improved over previously existing types of similar rubbers. The material is a product of Goodyear Tire & Rubber Co., Akron 16, Ohio.

Other nonmetallics

▸ Large silicon crystals in diameters up to 6 in. are now available from U. S. Semiconductor Products, Inc., Phoenix, Arizona. The crystals are made by a new growing technique. Potential uses include infrared prisms, tubes, lenses, correcting plates, recticles and photocell windows.

▸ Lower cost aluminum-coated paper may result from the vacuum deposition of aluminum on paper. According to F. J. Stokes Corp., 5500 Tabor Rd., Philadelphia 20, continuous coating of paper by the vacuum process can produce satisfactory results for 40 to 70% of the cost of laminating foil, depending on the base stock selected.

Finishes

▸ The S/S Israel of the American-Israeli Shipping Co., Inc., 42 Broadway, New York 4, arrived in New York City after a voyage during which the ship's underwater surface was protected from corrosion by an anode device trailed from astern. The method of corrosion control uses a specially prepared platinum-clad tantalum nickel rod attached to a flexible rubber-covered electrical cable.

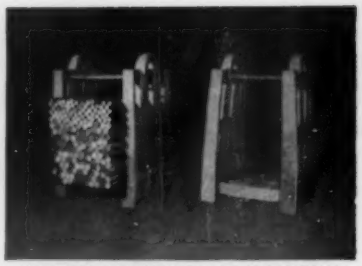
Joining materials

▸ An epoxy adhesive kit containing a pint of clear epoxy resin and five jars of powdered metals (aluminum, iron, stainless steel, brass and zinc) is being marketed by Carl H. Biggs Co., 2255 Barry Ave., West Los Angeles 64, Calif. The kit sells for $15.

▸ A foil welding machine capable of making welds on 0.078-in. stock at 3 to 24 fpm is available from Precision Welders & Flexopress Corp., Cincinnati, Ohio. The foil welding machine can be used for welding mild, low alloy, high carbon and stainless steel foil.

Testing equipment

▸ A test instrument has been developed for determining the crystallinity of parts made from TFE resins. The instrument is available from Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Waltham, Mass.



MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
E. W. Bliss Co., Canton and Toledo, Ohio
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Pattern & Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng Corp., Danville, Pa.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
The Prescott Co., Menominee, Mich.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

WRITE TODAY FOR YOUR FREE SINGLE COPY OF THIS INFORMATIVE BULLETIN.

BEHAVIOR OF CASTINGS AT ELEVATED TEMPERATURES — *BULLETIN TD-7*

Write today to Meehanite Metal Corporation, Department 3C, 714 North Avenue, New Rochelle, New York.

MEEHANITE®

For more information, circle No. 476

HEAT RESISTANCE

These Meehanite®, type HS, annealing baskets support over 2000 lbs. of bar stock castings during heat treat cycles at 1450°F for five hours without growth, scaling or premature cracking. They are made by Centrifugally Cast Products Div., the Shenango Furnace Co., Dover, Ohio.

Heat resisting Meehanite castings provide dependable service at high temperatures

Metal parts subjected to high temperatures undergo dimensional and structural changes which can lead to premature cracking or surface disintegration and scaling. These serious causes of failure can be avoided by selecting materials capable of withstanding the specific heat stresses involved.

The stabilized structure of Meehanite metal is particularly suitable for engineering applications where components must function dependably under steady or cyclic high temperature conditions.

This dependability of Meehanite® at elevated temperatures has led to its acceptance as a standard material for annealing pots, dies and fixtures, ingot molds, stoker parts, steel mill furnaces, smelting, cement and roasting furnaces, tube mill furnace rolls, incinerator liners, etc.

There are ten types of heat-resisting Meehanite metals available from which selection can be made according to conditions of service at high temperatures. For more detailed information write for a copy of our new, 4 page bulletin TD-7 — "Behavior of Castings At Elevated Temperatures" — or call the Meehanite foundry nearest you.

Test casting A, made from alloy gray iron was heat-treated for 300 hours at 1700°F in an oxidizing atmosphere. Severe growth and scaling is evident. Casting B, made from SC Meehanite® was given the same heat test. No growth or scaling occurred.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE NEW YORK

Graphite Specialties Can Solve Difficult Problems

Custom grades of graphite are regularly formulated by Graphite Specialties Corp., and furnished in extruded, molded and machined shapes to close tolerances to meet a wide range of difficult applications . . . *OR* GSC may be able to provide one of their many existing formulations to meet your requirements.

GRAPH-I-TITE: A collection of unique properties in one material, so valuable for such a wide diversity of uses, that GRAPH-I-TITE is furnished in two grades in standard sizes of rod and tube, as well as machined shapes. GRAPH-I-TITE possesses uniform high density . . . low permeability . . . immunity to thermal shock . . . resistance to corrosion at extremely elevated temperatures . . . and is not wetted by molten metals.

CARBO-TITE: Similar to "Graph-i-tite" except a carbon, rather than graphite base, and Carbo-tite is as hard as glass, and features a relatively *low* rate of thermal conductivity.

NUCLEAR: Purity grades to specified density for lowest neutron-capture cross section; highest scattering cross section for moderator, fuel elements, structural parts and piping and related equipment.

METALLURGICAL: Custom shapes and grades of graphite for special molds, dies, crucibles, boats, etc., for the chlorination of metals and other difficult applications.

MISSILES & ROCKETS: Recent developments make special grades of graphite particularly promising for nose cones, rocket nozzles and similar high temperature, high erosion applications.

MECHANICAL: Grades available with specified properties including temperature resistance to 5700°F., hardness to 5+ Mohs for bearings, seal rings, seats, etc.

FURNACES: In addition to graphite components for resistance and induction furnaces, Graphite Specialties Corp. designs, manufactures and installs complete ultra-high temperature furnaces for heating requirements as high as 5700°F.

CHLORINE HEATERS: Special furnace development has led naturally to manufacture of what is believed to be the first practical type of chlorine heater for any temperature requirement to 5700°F.

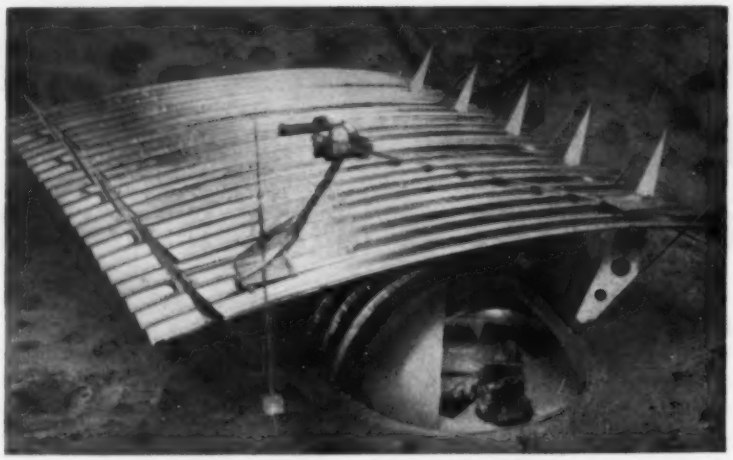
Write to GRAPHITE SPECIALTIES CORP., 64th & Pine Ave., Niagara Falls, N. Y.

For more information, circle No. 408

Magnesium—cont'd from p 12

New forming technique: *magnesium sheet is taped to aluminum master, inserted in air-exhausted plastic bag and placed in autoclave.*

metal autoclave bonding. In the technique, a magnesium blank is taped to a preformed aluminum master skin. The assembly is then padded and enclosed in a plastic bag from which air is exhausted. The magnesium is held to the aluminum contour by external pressure and the bag and contents are moved into an autoclave for cure under a uniform pressure and a temperature of about 350 F (see photo above).



Bug-like structure *is designed to withstand meteoric bombardment and violent weather changes on the moon.*

Aluminum Moon House May Have to Float

One answer to today's acute housing shortage is the aluminum house shown in the photo above. Unfortunately prospective occupants must be willing to relocate—about 240,000 miles, to the moon.

Actually the structure shown is a scale model of what is expected to be the first house on the moon. According to Wonder Building Corp. of America, the hermetically sealed building will be 340 ft long, 160 ft wide and 65 ft high. The arched shell of the building and the umbrella-shaped "meteoric shield" will be made of prefabricated, corrugated aluminum sheets secured by nuts and bolts and welding. No internal supports are necessary.

Aluminum was selected because of its light weight, reflective qualities and ease of fabrication. The structure is designed to either float on a sea of dust (some theories hold that

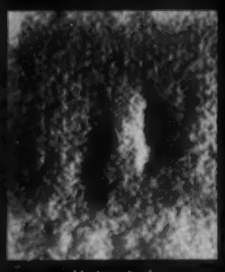
SPECIAL FELT TREATMENTS Increase Life, Improve Properties for Seals, Filtering and Cushioning

Never before has FELT been able to provide such a wide range of properties — for such applications as seals, filtering and cushioning! And Felters is continually experimenting with many combinations to provide designers with more and more versatility in felt, including use of the newest synthetics and plastics.

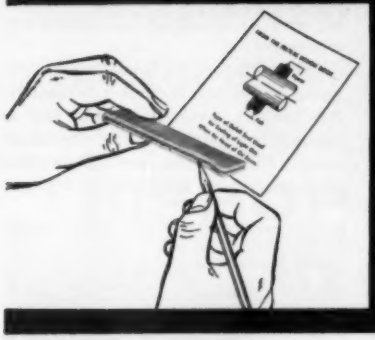
What do you want FELT to do?
Felters has pioneered in producing felts which have unusual properties for special applications.
Let Felters help you make felt do more jobs, more efficiently — with special treated or standard Cut Parts. Specific technical service is available from any Felters office.

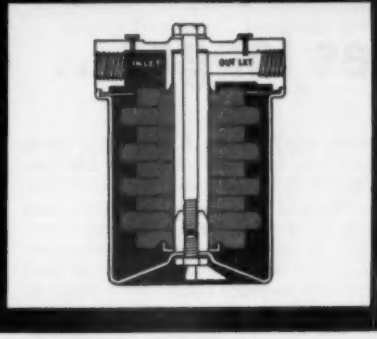
Send for Design Book . . .
for a complete digest of basic data on felt properties and uses.

Felters' Nylon-treated all wool Felt provides extra wear, superior resistance to scuffing, abrasion and friction. Extra strength without increased density. Each fiber encased in protective sheath of nylon. Porosity and resistance of felt unaffected. Wyzenbeck Wear Test of 6,000 strokes on Untreated versus Nylon Resin Treated Swatches demonstrates the difference.


Untreated

Treated





For Seals — Felters Dufelt is ideal for use as a seal with light oils, when no head of oil exists. Dufelt incorporates layers of Hycar, sandwiched with standard felts, in a number of different combinations.

Felters' Filtering Felts assure uniform densities for filtering a wide range of liquids and air. Includes oil, latex, cellulose products, gasoline, alcohol and similar media. Capillary value controlled by varying fibre density and grade.

Vibration Isolation and Cushioning can be effectively achieved by using special Unisorb Pad or Unisorb Level-Rite machine mounts. Prevents transmission of vibration to surroundings, improves operation of machine tools.

the **FELTERS** company
220 SOUTH ST., BOSTON 11, MASS.
Pioneer Producers of Felt and Felt Products

For more information, turn to Reader Service Card, circle No. 456

SHARPLES

SUPER-D-HYDRATOR

More than 400 of these centrifuges are now in service, with a combined daily capacity in excess of 1,600,000 cubic feet.

"Wear parts" made from KENNAMETAL help keep production high, downtime low

Against $(NH_4)_2SO_4$

KENNAMETAL* components last 2 to 6 times longer...

On Unloader Knives: When processing corrosive Ammonium Sulfate (Coke Plant), the best life of any material tried for unloader knives on this crystal dehydrator was less than three months.† With Synthetic Ammonium Sulfate, the knives lasted little more than a month. By changing to knives made from Kennametal hard tungsten carbide, service life has been increased to twelve months or more with Coke Plant Sulfate, and up to four months with Synthetic Sulfate.

On Distributor Tips: With sulfates of either kind, Kennametal Distributor Tips in the feed assembly last up to eight months—double the life of any other alloys tried. Kennametal parts cost less in terms of longer life, increased production, and less downtime.

Chances are Kennametal can help *you* solve a problem involving corrosion, abrasion, erosion, or contamination. The Kennametal "family" of hard carbides includes grades three times as rigid as steel . . . grades that last up to 60 times as long as steel . . . grades that retain high strength at 2200°F and above or at subzero temperatures.

Let us tell you more about Kennametal and how it has helped others solve problems that may be similar to yours. Write to KENNAMETAL, INC., Dept. MDE, Latrobe, Pennsylvania.

2198

*Trademark
†Based on an average daily throughput of 100-150 tons.

INDUSTRY AND KENNAMETAL ...Partners in Progress

For more information, turn to Reader Service card, circle No. 417

MATERIALS AT WORK

the moon's surface is composed of fluffy, powder-like dust several miles thick) or rest on solid ground. Purpose of the building (which the designers expect to be placed on the moon in ten years) is to observe and study outer space, the moon and the earth.

Melamine Housings Cut Cost of Photocopier

A piece of equipment normally made of stainless steel and plastics has been redesigned to eliminate the stainless in favor of all-plastics construction. The result: a cost and weight saving of 4:1 and a substantial increase in break resistance.

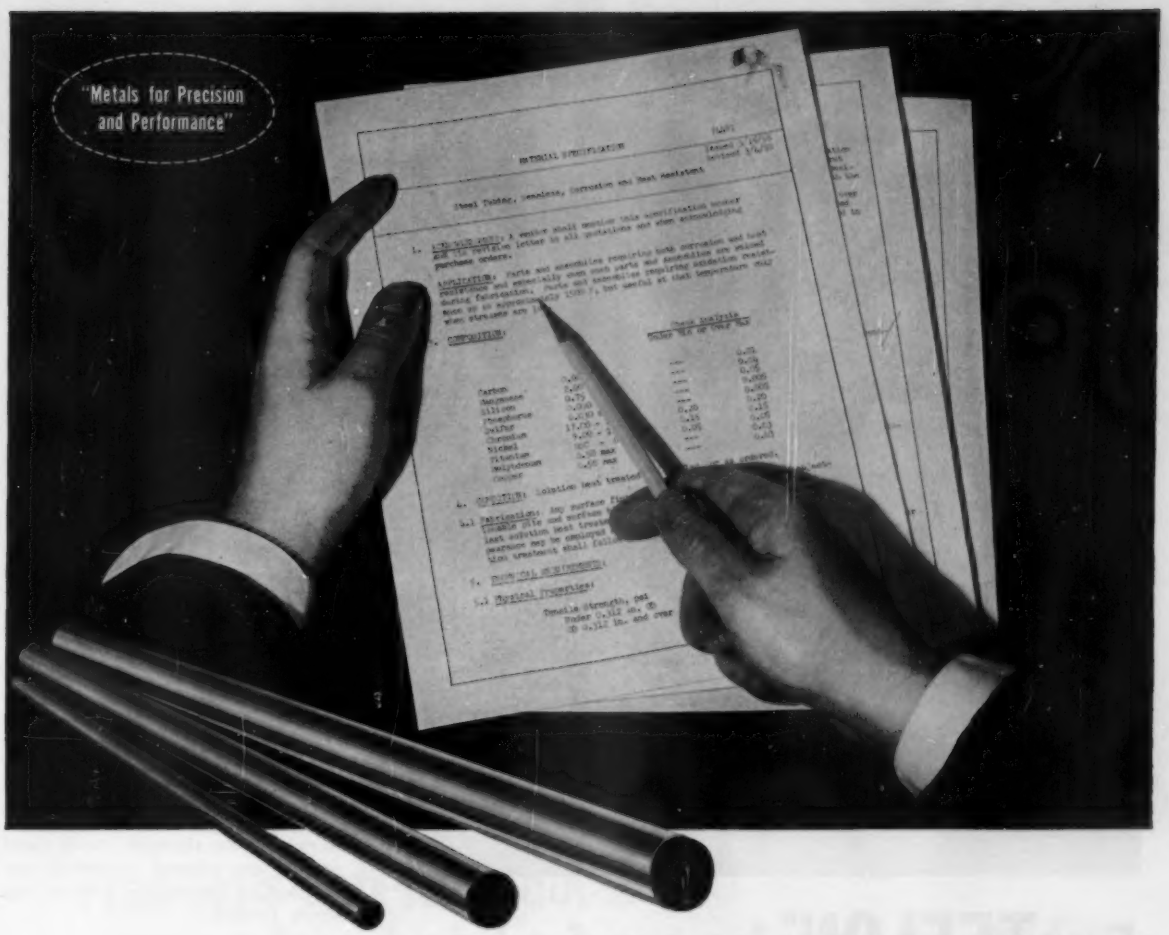
The unit, a photocopying machine manufactured by American Photocopy Equipment Corp., previously used a stainless steel housing and cover. Now, molded melamine is used. According to the company, the use of melamine reduced retail cost by about $100.

Lower cost and weight were not the only reasons for replacing stainless steel: 1) the molded melamine housings permit design features which would prove too costly in a drawn metal housing; 2) the parts can be turned out with color molded in; and 3) finishing operations are minimized.

Other important plastics components in the unit include a replenishing tank, a processor tank, and a removable trough for the processor tank. These units are all molded of transparent acrylonitrile-styrene

Chicago Molded Products Corp.

***Redesigned photocopier** is four times lighter and less expensive as a result of the switch from stainless steel to molded melamine.*



your individual tubing specs are a **BISHOP specialty**

That special tubing you need doesn't have to be a frustrating problem — BISHOP delights in tackling tough specs. BISHOP is uniquely equipped to handle specials—long on experience and capacity, short on delivery. You'll get help within 24 hours from a Quick Service Team of sales, metallurgical and production experts—and unexcelled quality tubing . . . the finest made.

Briefly, the Bishop Line . . .

STAINLESS STEEL TUBING Seamless, Welded & Drawn	Mechanical, Aircraft, Capillary, Hypodermic also NEW Stabilized and L grades, precipitation hardening alloys	0.008" to 1.000" OD 0.003" to 0.083" wall
NICKEL & NICKEL ALLOY TUBING	All standard grades	up to 1.000" OD 0.065" wall max
TUBULAR FABRICATED PARTS	Flanged, flared, milled, slotted, swaged, threaded	
GLASS-TO-METAL SEALING ALLOYS	Low expansion alloys for glass sealing applications	
CLAD METALS & COMPOSITE WIRES	Base metals & precious metals in various combinations	
PLATINUM GROUP METALS	Fabricated products—chemicals	
CATALOGS, DATA SHEETS ON THE ABOVE SENT PROMPTLY ON REQUEST		

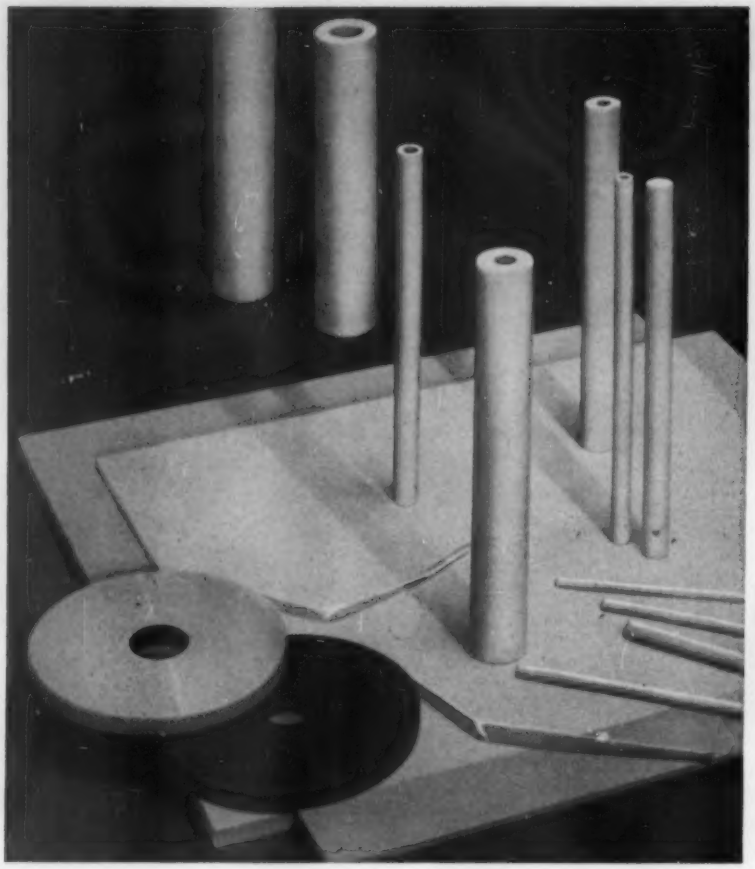
Send in your individual specs for prompt handling, thorough analysis, prices, deliveries. Write, wire or phone Malvern 3100, or call your local steel service center.

AMERICAN STEEL WAREHOUSE ASS'N

Tubular Products Division

J. BISHOP & CO.
platinum works
MALVERN, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 364



For TEFLON* in any form...
CALL ON R/M

Benefit from Raybestos-Manhattan's long experience in the use of "Teflon" and ample facilities for its fabrication. Whether your needs can be met by stock sizes and shapes or require custom made parts, R/M can help you.

R/M makes a broad range of rods, tubes, thin wall tubing, bondable tape and sheets—and new sizes are constantly being added. One of the newest sizes, for example, is 1/32-in.-thick "Teflon" in 36 x 36 in. sheets.

Where custom fabrication is needed, R/M is equipped to extrude, mold or machine "Teflon"—the choice depending on your individual design and quantity requirements.

Whenever "Teflon" is to be specified in a design, don't hesitate to contact your nearest R/M district office for friendly, competent help. And write now for informative literature.

*A Du Pont trademark

RM

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

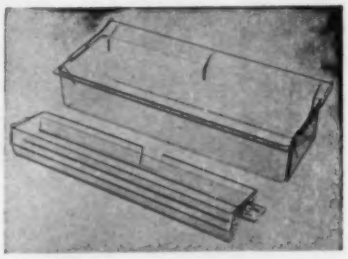
BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber
Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

For more information, turn to Reader Service card, circle No. 470

MATERIALS AT WORK

***Melamine** housing and cover require no finishing and offer integral coloring and wide latitude of design.*



***Acrylonitrile-styrene** tank and trough are impact resistant, unaffected by developing solution and easily formed.*

copolymer because it offers high impact resistance, is unaffected by the developing solution and, in the case of the replenishing tank, allows visual observation of the solution level. In addition, various gears, pulleys, bearings and inserts are molded of nylon.

Zinc Die Casting Replaces Cast Iron

The change from cast iron to die cast zinc has resulted in the elimination of many expensive machining costs in the production of electric motor bearing lock rings.

According to Baldor Electric Co., the following operations are eliminated: face milling; machining of

SOURCES of most engineering materials can be found in the second edition of M/DE's *Materials Selector* reference issue, published last October. Properties of all materials are also given.

Experience**—the extra alloy in **Allegheny Stainless

ANTI-ICING DUCTS, made from Allegheny Ludlum AM350, are designed to withstand temperatures to 700F and pressures to 200 psi. Wall thicknesses .025 in. to .187 in.; outside diameters, 1½ to 4½ in.

made from Allegheny Ludlum precipitation-hardening stainless:

Prop-jet's anti-icing ducts take high heat and pressure in stride

The anti-icing system of a new prop-jet airliner was designed to operate under high heat and pressure, yet the ducting had to be as light as possible. AM350 was specified. Both AM350 and AM355, Allegheny Ludlum's precipitation-hardening stainless steels, have strength/weight ratios at 600F five times greater than the usual aluminum aircraft alloy. In fact, AM350 and AM355 maintain high strength from room temperature up to 1000F.

These space age metals have other properties highly desirable: excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

These features have been used to advantage in airframe structural members, airframe skins, pressure tanks, power plant components, high pressure ducting, nacelles and other missile and supersonic aircraft applications.

availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars and wire.

corrosion resistance: Compared to the more familiar stainless grades, AM350 and AM355 resist corrosion and oxidation better than the hardenable grades (chromium martensitic) and only slightly less than the 18 and 8's. They resist stress corrosion at much higher strength levels than do martensitic stainless grades.

simple heat treatment: High strength is developed by two methods. Both minimize oxidation and distortion problems. The usual is the Allegheny Ludlum-developed sub-zero cooling and tempering (SCT): minus 100F for 3 hrs plus 3 hrs at 850F. Alternate method is Double Aged (DA): 2 hrs at 1375F plus 2 hrs at 850F.

easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using normal stainless procedures. In the hardened conditions, some forming may be done . . . 180 degree bend over a 3T radius pin. Also AM350 can be dimpled in the SCT condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.* Address Dept. MM-13.

WSW 7341

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

For more information, turn to Reader Service card, circle No. 426

Federal Short Run Stampings may be your answer

Consider these advantages Federal "Controlled Tolerance" Short Run Stampings can give you. First, a *savings* of up to 80% of the cost of conventional tooling methods. Second, *quicker delivery* due to our special methods of tooling and manufacturing. Third, *quality* component parts made exactly to your specifications by skilled craftsmen using modern methods on modern machines. They all add up to quality stampings in any quantity from two pieces to 10,000 of any stampable material up to 10" x 14" in size and up to 3/8" thick. Send your print or part to nearest plant for a Federal Analyzed Quotation.

Write for free Catalog 201. Tells how to reduce costs by using short run stampings . . . full of design tips.

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7352 Atoll Ave., No. Hollywood, Calif.

For more information, turn to Reader Service card, circle No. 474

American Zinc Institute

***Zinc die casting** (shown in two views at right) eliminates costly machining previously necessary with cast iron part (left).*

a locating ring groove; boring a shaft hole; and drilling screw holes.

Zinc was selected because of its excellent die casting properties, corrosion resistance and ability to be held to close dimensional tolerances.

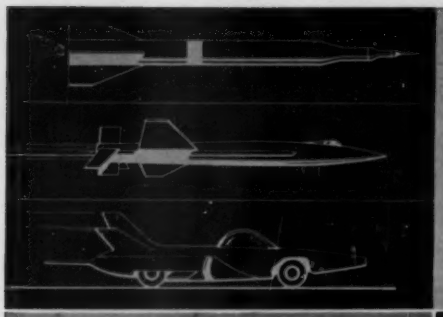
The zinc bearing lock ring is die cast to size with the bore holes and locating ring held to within ±0.002 in., as cast. The cored screw holes are cast to size in the same operation.

Plastics 'Copter Blades Protected with Steel

A 0.019-in. thick strip of stainless steel has overcome severe abrasion problems encountered in the use of reinforced plastics rotor blades for helicopters.

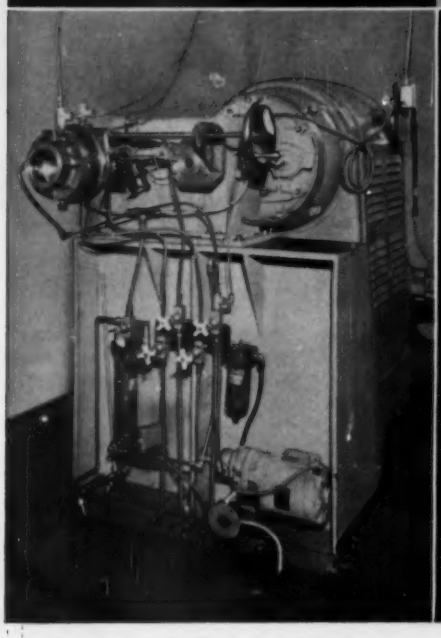
According to Republic Steel Corp., when a helicopter takes off from an unsurfaced area, a miniature sandstorm is churned up and the rotor blades must cut through dense clouds of dust at speeds up to 500 mph. At this velocity, the razor-sharp particles of grit bite into the leading edge of each blade like a powerful sandblast.

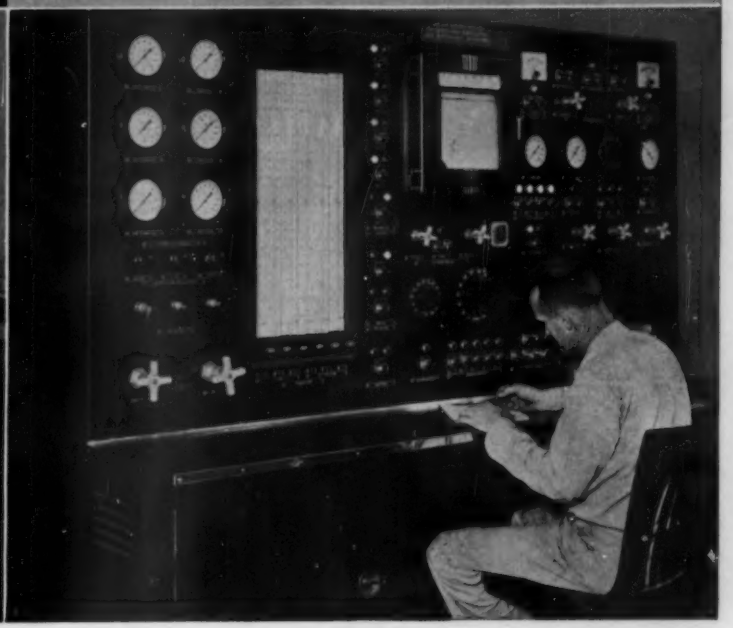
To solve this problem, a metal shield made of 302 stainless steel is cold worked to the shape of the leading edge and bonded to the plastics body. Although any of several metals would have provided satisfactory protection for the plastics blades, stainless was chosen be-



Breakthrough

at 80,000 R.P.M.!





New C/R high-speed laboratories ...testing seals at tomorrow's speeds!

Pushing a design program through on schedule means that there can be no slow-down in any phase. If you know there's a high-speed sealing problem ahead — an accessory drive for a new jet, a hot, fast-rotating shaft in a guided missile, or a bearing in tomorrow's turbine car — plan for it now. Here in Chicago Rawhide's new High-Speed Seal Test Laboratory, C/R engineers now are breaking through present limits, evaluating the design and performance of advanced seal types such as end face, controlled gap, bellows, segmental and bore type seals under such punishing conditions as 80,000 R.P.M., –300° to +1000°F. and 500 psi. C/R is at your service *now* with the most advanced technology and facilities in the country for cooperative research on high-speed sealing problems.

Chicago Rawhide consistently gears itself to the future, ready to meet industry's new problems as they develop today. May we help you?

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.

In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.

Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

OIL SEAL C/R DIVISION

CHICAGO RAWHIDE

For more information, turn to Reader Service Card, circle No. 388

Stalwart Announces

SILICONE SPONGE RUBBER...

in extruded and calendered shapes

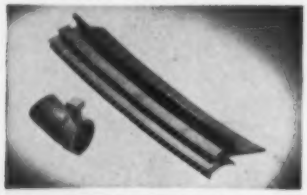
Exclusive new processes produce cross sections, lengths and densities to your specifications

Here is important news for designers in the appliance, aircraft, electronics and other industries! A unique process developed by The Stalwart Rubber Company now enables silicone rubber to be extruded and sponged in complex configurations or calendered to close tolerances to meet customer specifications. Here are the facts... Stalwart extrudes silicone sponge parts in 1/16 to 8-inch dimensions in lengths up to 300 feet. Calendered sheets are produced in widths up to 36 inches. These silicone sponge parts resist sunlight, ozone, and aging as well as temperatures ranging from −160° to +500°F. Stalwart also mass-produces all types of precision parts from natural and synthetic rubbers.

Send today for your copy of the new Stalwart Catalog.

8302-SR

Cell sizes range from very coarse to fine with open or closed cell-structures.



Silicone sponge extrusions can be combined with solid silicone rubber extrusions.

Calendered and extruded silicone sponge shapes can be covered with heat-resistant fabric.

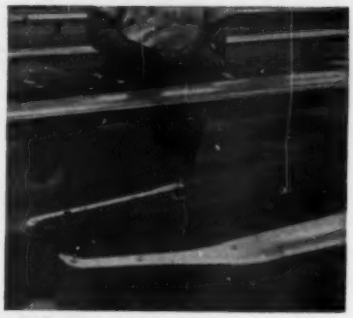
Another first by

STALWART RUBBER COMPANY

165 NORTHFIELD ROAD • BEDFORD, OHIO

PLANTS in BEDFORD, OHIO and JASPER, GEORGIA.

For more information, turn to Reader Service card, circle No. 442



***Stainless steel strip** is applied to leading edge of plastics blades.*

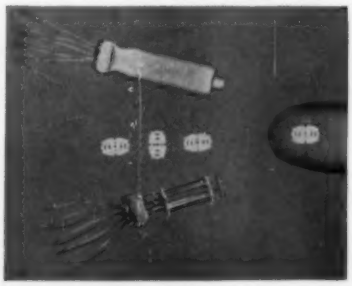
cause even slight rusting or pitting could upset the closely matched balance of sets of blades and create dangerous vibrations.

Precise Mica Spacers Protect Electron Tubes

The mica insulating disks shown in the accompanying photo measure only 0.008 in. thick by 0.3 in. long and contain seven accurately spaced alignment holes—yet they are stamped to tolerances of ±0.001 in.

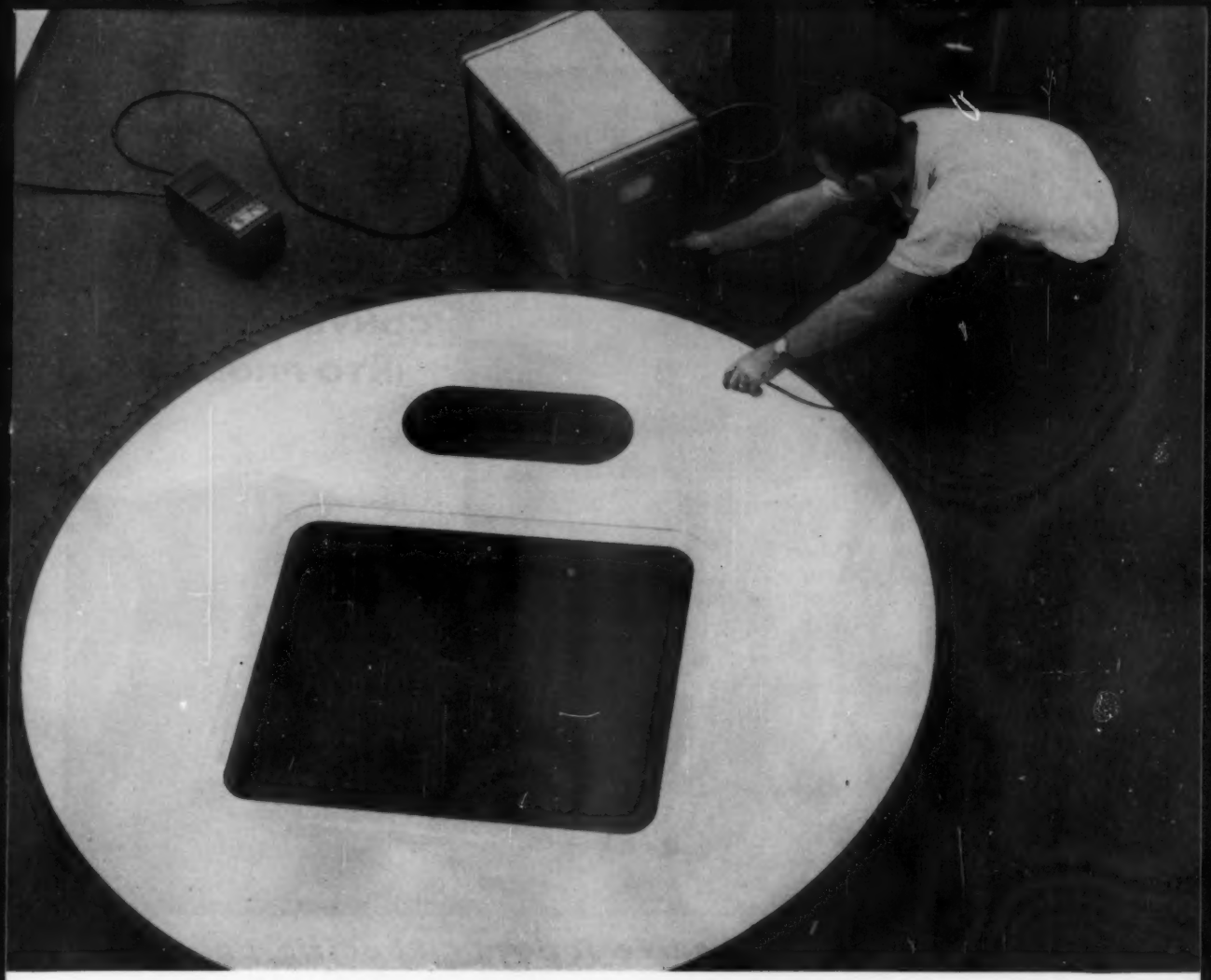
The disks, stamped from natural muscovite, are used to insulate (electrically and thermally), protect and align miniature electron tubes in critical missile and communication equipment. With the disks in place, tubes are said to be capable of withstanding impact and acceleration shocks of 450 and 1000 g's, respectively.

Overall tube dimensions are ⅜ × 1½ in. According to Ford Radio and Mica Corp., the disks are probably the smallest tube spacers made.



***Tiny mica disks** are stamped to tolerances of ±0.001 in.*

For more information, circle No. 468 ▶



"test soundings"

. . . prove the soundness of Carlson stainless steel plate

"HEAVING THE LEAD" may be the traditional way to keep a boat off the shoals, but modern sound wave instruments do it faster and better. And, for a very different reason, modern sound wave devices are used to assure quality stainless steels. Carlson was one of the first producers to use ultra-sonic equipment for testing heavy gauge stainless plate.

In ultra-sonic testing, sound waves take a penetrating look inside and positively determine structural quality. A complete report on the results of the test is supplied to the customer. By specifying ultra-sonic tested plate, builders of aircraft components and nuclear equipment can tell in advance that the material will meet their rigid requirements.

Ultra-sonic is only one of the many tests used to maintain the high quality of Carlson stainless plate. The final, and most important test, is when *you* get repeat orders from *your* customers.

Write, wire or phone for complete information on all Carlson services.

G. O. CARLSON Inc.

Stainless Steels Exclusively

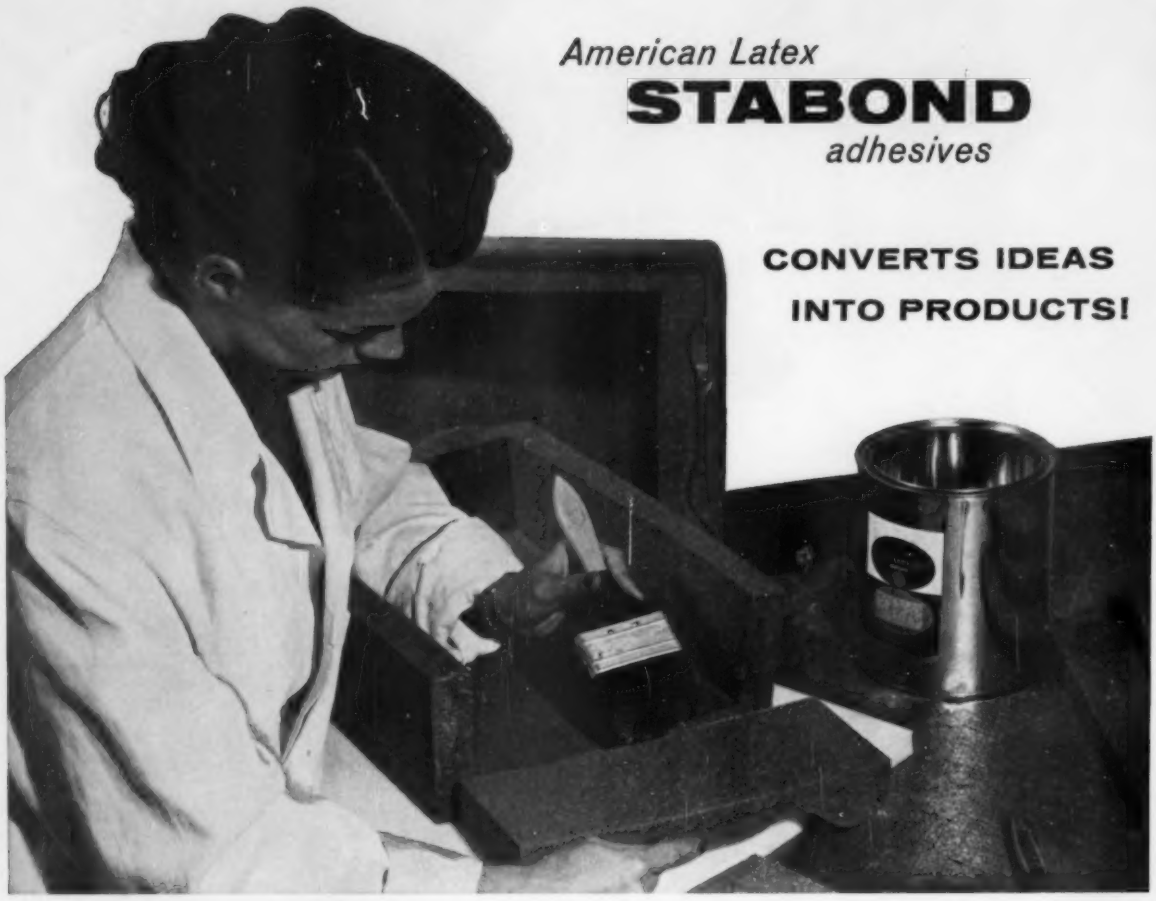
126 Marshallon Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS AND SHEETS (No. 1 Finish)

American Latex

STABOND

adhesives



CONVERTS IDEAS INTO PRODUCTS!

The dependable adhesive for your specific purpose

Years ahead in the formulation and production of "specific purpose" cements and adhesives, STABOND meets today's demands for a stronger, more dependable adhesive. Among many bonding applications, STABOND is used almost exclusively for the fabrication of urethane materials.

For instance, the STABOND adhesion of polyurethane foam to itself or to dissimilar materials can and will...

1. be the ONLY SATISFACTORY fastening method.
2. result in substantial labor and materials savings since STABOND adhesives provide continuous flexible seals requiring less cutting and contouring.
3. simplify assembly of polyurethane foam components and contribute to the flexibility of the overall design.
4. provide seam areas that are as strong as the foam yet remain soft, flexible and virtually indistinguishable from the foam.
5. provide neat, smooth exterior surfaces at the seam area particularly if an overcoating is employed.

FLEXIBLE POLYURETHANE TO ITSELF

T-100 A clear, high quality rubber base adhesive made as transparent as possible to assure a minimum visibility seam line.
Solids content - 10-12% Service temp. - 0°-200° F.

T-161 A light amber, neoprene rubber base adhesive giving longer tack period than T-100 and higher viscosity.
Solids content - 22-25% Service temp. - 20°-200° F.

FLEXIBLE OR RIGID POLYURETHANE TO DISSIMILAR MATERIALS

C-511 A tan colored, buna N base adhesive which provides a tough, flexible bond between dissimilar bonded components. Qualifies to military spec.
Solids content - 30-32% Service temp. - 45°-300° F.

H-144 A light colored, pressure sensitive type adhesive made from a rubber base stock. Provides quick grab and long tack period for temporary bonds to porous and non-porous surfaces. Strips clean and virtually mark free.

AMERICAN LATEX
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STABOND ADHESIVES

A complete research and development staff and facilities are available for new product applications. Please call or write for additional and/or technical STABOND *information.*

For more information, turn to Reader Service card, circle No. 464

PRICES AND SUPPLY

...AT A GLANCE

STEEL PRODUCTION WILL BE INCREASED by 20-30% in 1959, predicts Thomas F. Patton, president of Republic Steel Corp. Mr. Patton's prediction is based on expectations of increased production in steel-using industries: auto production is expected to rise 30% (to about 5.5 million units); construction is expected to use 20% more steel; and inventory build-up should increase by about 50%.

POLYPROPYLENE PRICES HAVE BEEN REDUCED 7¢ per lb by Montecatini Chemical Co., Milan, Italy. According to Lucio Lucini, president of Chemore Corp., Montecatini's U.S. representatives, natural resin is now 49¢ per lb and standard colors are 58¢ per lb.

TITANIUM SPONGE PRICES WERE REDUCED by Du Pont late last year. New prices are: $1.82 per lb for A-1, down from $2.05; and $1.70 per lb for A-2, down from $1.85. Last April, A-1 was reduced from $2.25 and A-2 from $2.00. Ten years ago the price was $5.00 per lb.

PRODUCTION OF CAPROLACTUM MONOMER—the basic raw material for nylon molding resin and fiber—will be substantially increased as a result of Allied Chemical Co.'s expansion and Du Pont's entry into the field. Allied's new plant, scheduled to go on stream early this month, will have an annual capacity of 60 million pounds. Du Pont will enter the field late in 1960 with a plant scheduled to produce 50 million pounds per year.

COMMERCIAL QUANTITIES OF DELRIN, Du Pont's new acetal plastic, will be available in mid-1959 at an initial price of 95¢ per lb. According to R. J. Manning, product manager, the price should decrease as uses and sales volume increase. The new material is said to have a combination of properties which makes it suitable for automobile parts, industrial machinery, packaging, electrical equipment and appliances, pipe, plumbing fixtures and other uses.

A NEW SOURCE OF ASBESTOS FIBER promises to supply 100,000 tons per year for at least the next 20 years. The new installation, owned and operated by Lake Asbestos of Quebec, Ltd., a wholly-owned subsidiary of American Smelting & Refining Co., will increase the free world supply by about 7%. This increase assures a more than ample supply for the future.

See Other News on p 175

IN UTILITY...IN LASTING BEAUTY... THERE'S NO MATCH FOR STAINLESS STEEL

That's why designers specify stainless for so many places where other metals just won't do. For no other metal combines so much *utility* and *solid, lasting beauty!* Stainless steel resists corrosion and denting. It doesn't peel or rust. It can be made "new" again with mere soap-and-water washing. So remember — if the design calls for beauty that simply won't wear out, specify stainless steel. Remember, too, that the very best stainless steels are made with Vancoram Ferro Alloys! Vanadium Corporation of America, 420 Lexington Ave., New York 17, N. Y. Producers of alloys, metals and chemicals.

VANCORAM

VANADIUM CORPORATION OF AMERICA

For more information, turn to Reader Service card, circle No. 486

PRICES AND SUPPLY

Other News . . .

▸ Prices of carbon and graphite electrodes, graphite anodes and miscellaneous carbon and graphite products have been increased by approximately 5% by National Carbon Co., Div. of Union Carbide Corp.

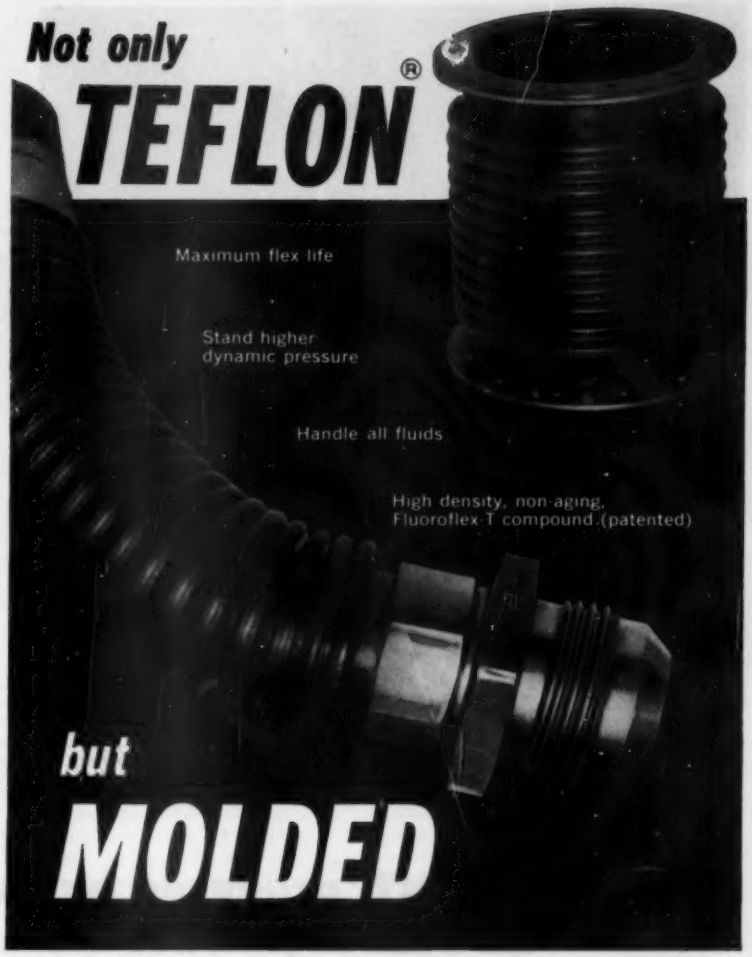
▸ Production of polypropylene on a pilot-plant scale has been started by Eastman Chemical Products, Inc. According to the company, the key to its new polypropylene plastic is "the discovery of new catalysts" which are covered by U.S. and foreign patents. The company declined to say when the new material would be commercially available.

▸ The nation's first integrated, privately-owned plant for the fabrication of beryllium metal has been put into operation by Beryllium Corp. The only other complete beryllium fabrication plant in the U.S. is owned by the U.S. Atomic Energy Commission. The company plans to produce parts both for nuclear applications and for aircraft research.

▸ Teflon rod prices have been cut by as much as 20% by Tri-Point Plastics, Inc. The new prices apply to the entire range of over 50 diameters of rod ranging from 0.125 to 2.0 in.

▸ Production of cellular plastics during 1958 probably amounted to a little over 50 million pounds, according to Joseph R. Morton, chairman of the Cellular Plastics Div., Society of the Plastics Industry. This figure represents an increase of about 59% as compared to production in 1957. Production estimates of specific materials are: flexible and rigid vinyl foam—5¼ million pounds, up from 4½ million; flexible and rigid urethane foam—28 million pounds, up from 12 million; and rigid polystyrene foam—20 million pounds, up from 15 million.

▸ Use of synthetic rubber continues to increase—at the expense of natural rubber. In 1958, "synthetic rubber supplied about 64½% of the total new rubber requirements in the United States," according to J. Ward Keener, president and chief executive officer of B. F. Goodrich Co. Consumption of synthetic rubber in 1959, Mr. Keener predicts, will be about double that of natural rubber. Among the reasons given for this trend are "high quality of man-made rubber and price stability." Synthetic rubber is currently selling for 23¢ per lb; since 1954, natural rubber has fluctuated from 19½ to 52¢ per lb.



Combine optimum chemical inertness of Teflon with unique strength and flex life achieved by *molding* and you have the big difference in bellows. Molding gives undamaged grain structure . . . uniform convolutions that don't fatigue and crack.

Unequalled flex life – Fluoroflex®-T, a special compound of Teflon, molded into bellows configurations, gives 20 to 30 times the flex life of bellows ordinarily machined from Teflon.

Work over wider pressure range – Molded bellows maintain full working pressures, even *after flexing.*

Corrosion-proof – universally useful with all chemically active and corrosive fluids, hot oils, steam, etc.

Range of styles and sizes: Available with special bellows configurations and couplings; also with ductile iron flanges, and ASA bolt circles.

Send for data. Write Dept. 172 RESISTOFLEX CORPORATION, Roseland, New Jersey. Other Plants: Burbank, Calif.; Dallas, Tex.

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®Teflon is DuPont's trademark for TFE Fluorocarbon resins.

RESISTOFLEX

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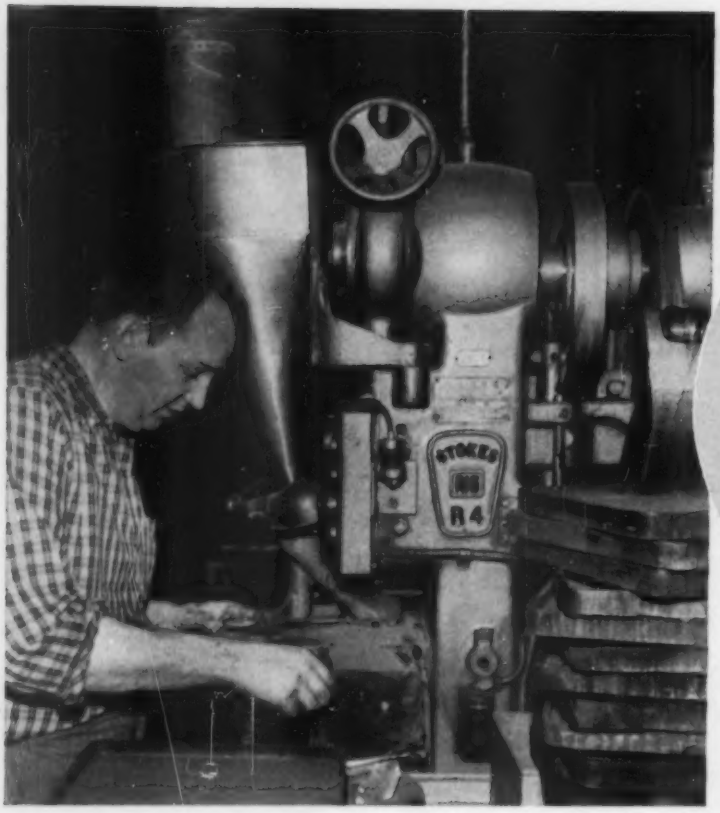
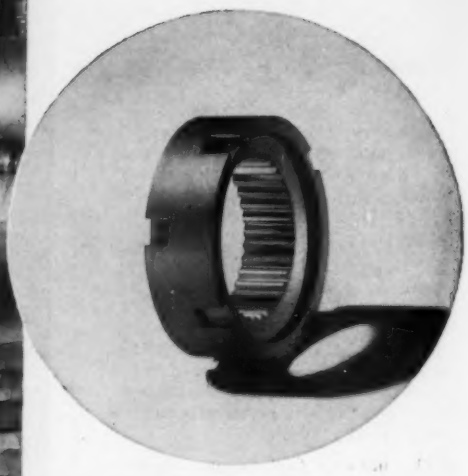




68% SAVINGS were realized on the piece shown above—a tractor part made from an iron base metal powder and having a tensile strength of 65,000 psi and an average hardness of 65 Rockwell B. The part was previously made by screw machine methods. At left, a Burgess-Norton operator checks the output of one of the Stokes R-4 Powder Metal Presses at the company's Geneva, Illinois, plant.

"Quali-SINT"® produced by Burgess-Norton on Stokes powder metal presses

Burgess-Norton Mfg. Co., Geneva, Illinois, is a leading producer of a wide variety of parts by powder metallurgy—including cams, spacers, gears, adapters, ratchets and pawls. The company maintains its own extensive engineering, metallurgical, and chemical laboratories, tool-making, and secondary machining and grinding facilities.

Five Stokes powder metal presses are operated 5 days a week—16 hours a day—to keep pace with their production demands. The number of parts per minute depends on the part and the process being used—only minimum operator attention is required. All 5 presses were chosen by G. W. Waller, Vice President of Engineering, on the basis of "(1)—Production rate per dollar cost, (2)—Minimum maintenance requirements, and (3)—Price."

Continual research and advancement in the field of powder metallurgy has made Stokes the recognized leader in this modern industry. Stokes achievements may well be the answer to meeting your own production requirements economically—and at high speeds. Ask for complete information on the Stokes line of industrial compacting presses—or for assistance by Stokes Engineering Advisory Service. Call—or write—today.

®"Quali-SINT" is a registered trademark of Burgess-Norton Mfg. Co., Geneva, Ill.

Powder Metal Press Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service card, circle No. 437

ISO Standards Clarify Language of Plastics

What does an impact strength value of 80 cm-kg per sq cm mean to an engineer accustomed to dealing with ft-lb per in.? Very little. And any conversion attempted from one system to the other is, at best, questionable.

Eliminating such problems in communicating technical information between countries is one of the important aims of the International Organization for Standardization (ISO). Last November, ISO Technical Committee 61 on plastics held its 8th annual meeting in Washington, D.C. and, despite the fact that international standards are understandably slow in developing, made considerable progress.

As a result of 14 sessions conducted by 56 delegates from 12 member nations, the following actions were approved; five recommendations (roughly comparable to ASTM recommendations); six proposals (which must be approved by members and passed through several review steps before becoming recommendations); and a number of future standardization projects. Specific results of the meeting of interest to designers and engineers were approval of the following:

1. A list of about 800 equivalent terms related to plastics in English, French and Russian. (Four other languages—German, Italian, Spanish and Polish—are included in the appendix).

2. Recommendations for: standard atmospheres for conditioning and testing of plastics materials, and melt flow index of polyethylene and polyethylene compounds.

3. Draft proposals for: determining tensile properties of plastics; testing of plastics with a torsion pendulum; use of the Vicat softening point test method; and methods of test for tracking of electrical insulation under moist conditions.

Future activities planned by ISO/TC-61 include: 1) development of specifications for both thermosetting and thermoplastic materials; 2) establishment of a working group to study cellular plastics; and 3) standardization of tests for impact, hardness and modulus of elasticity.

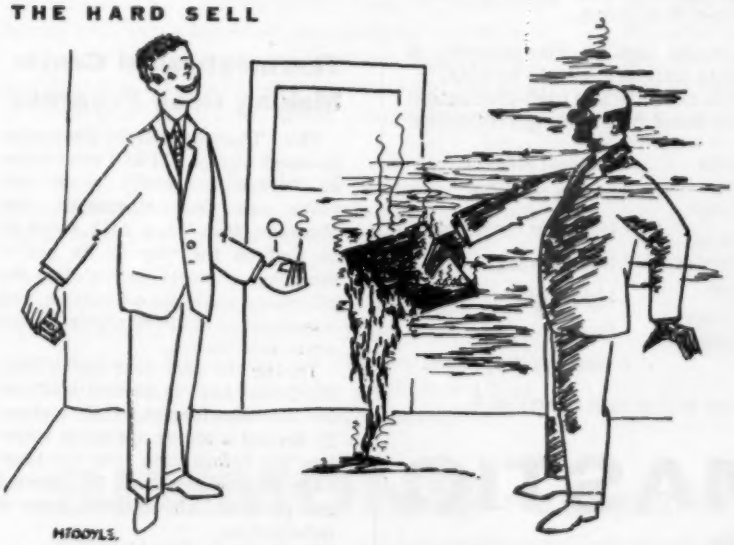
What is ISO?

ISO was set up in 1946 as an international body to promote international standardization. It is not affiliated with the United Nations; however, the U. N. recognizes ISO and refers matters on standards to it. At present, there are 40 member nations, each represented by its own national standards body, such as the American Standards Assn. for the United States.

ISO standards for engineering materials are largely based on accepted national standards, such as American ASTM standards or British BSI standards. However, as Dr. G. Kline, chairman of the 8th meeting of ISO/TC-61, pointed out, ISO must sometimes develop new materials standards in areas where no national standards exist or where developed standards are lacking in some respects.

There are 92 technical committees in ISO. Fifteen of the 92 relate directly to engineering materials. These are: paper; steel; zinc and zinc alloys; cast iron; copper and copper alloys; refractories; materials for paints, varnishes and similar

THE HARD SELL



"Well, what do you mean by 'self-extinguishing'?"

If you have a problem concerning high-heat protection of metal surfaces up to 4500°F, our Technical Service Department may be of valuable service to you. This service goes far beyond data sheets and specimens. Without cost or obligation, our engineers will analyze your requirements and make specific recommendations based on certified performance data. If necessary, we will visit your plant to confer with your engineers and study the problem first hand.

The practical answer to your problem could well be Flamemastic, a remarkable insulation coating that protects ordinary metals to 4500°F. Thoroughly proved in the torrid combustion chambers of high-production missiles for over 4 years, Flamemastic has these outstanding properties:

- Effective insulation from −100°F. to 4500°F.
- Fire resistant and retardent.
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- Fast, economical to apply by spraying, rolling or troweling.
- Can be applied to all ferrous or non-ferrous metals.
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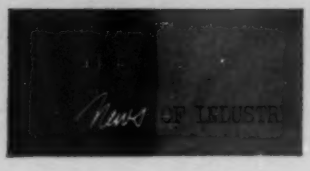


products; textiles; welding; rubber; mica; plastics; concrete; light metals and their alloys; and cork.

New Trend Evident at Plastics Show

The trend toward greater emphasis on development and extensive engineering study of plastics materials before they are made available to the designer was clearly demonstrated at the recent 8th National Plastics Exposition. This approach is in sharp contrast to that often taken in the early days of the plastics industry.

Consistent with the new approach, no startling new "break-throughs" were announced; instead, interesting new plastics developments were in the form of modification and development of formulations, compounds and forming techniques.

The show, which was sponsored by the Society of the Plastics Industry and held concurrently with the annual Technical Conference, was visited by approximately 30,000 people. Over 200 exhibits presented a comprehensive view of the industry's growth over the past two years.

For details on specific new developments see next month's issue.

Thermophysical Center Making Good Progress

The Thermophysical Properties Research Center (TPRC) established at Purdue University about two years ago (see MATERIALS AND METHODS, May '57, p 249) seems to be well on the way to its goal—becoming a world center for the collection, analysis, correlation and dissemination of thermophysical properties information.

During the past year and a half, the Center has: 1) devised a scheme for the classification of all matter; 2) devised a coding system to translate the information into the language of machines; and 3) collected and processed about 21,000 items of information.

Scope broadened

Originally, the Center planned to cover only seven of the thermophys-

stitching together a giant radome

Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

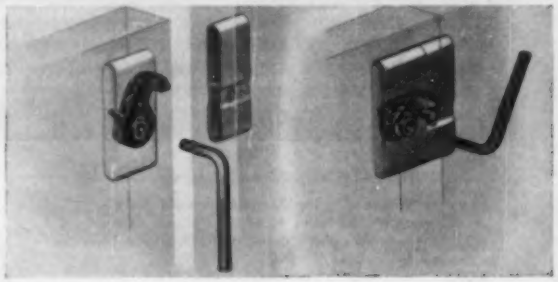
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



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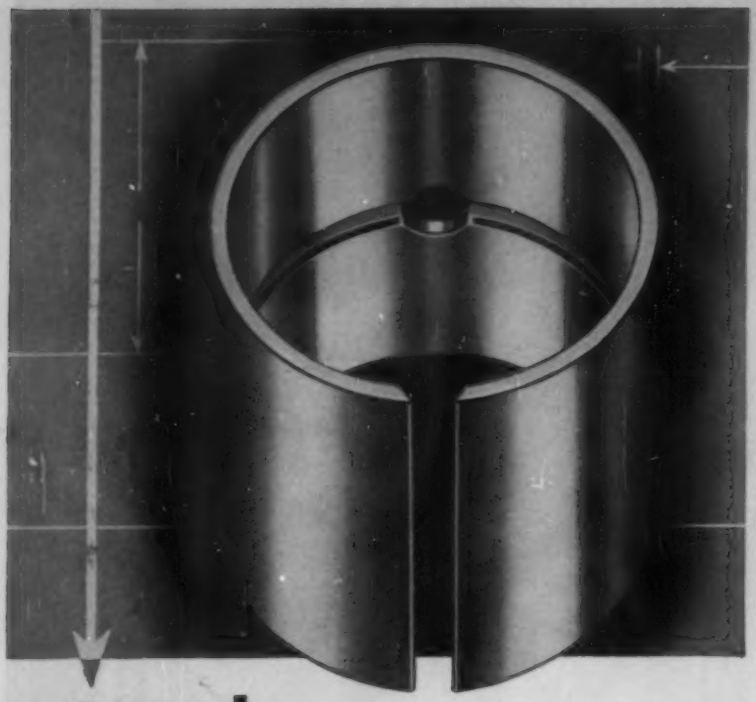

extremely rigid specifications!

The illustration shows the cast bronze spindle bearing of a very well-known and popular metal-working lathe.

The manufacturer of this lathe has extremely rigid specifications covering tolerances, finish, structural quality of the bronze and roundness of the bearing even though the bearing is split for its entire length.

A manufacturer with such requirements naturally turns to Bunting to satisfy them.

For the unusual, as well as the usual, in bearings, bushings, bars or special parts of cast bronze or sintered metals, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

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Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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ical properties of the more technically important gases, liquids and solids. Now, the Center intends to cover all thermophysical properties of all materials over the entire range of temperatures and pressures.

The Center's ultimate objective is to provide the following three kinds of information:

1. Theoretical methods of determining properties of gases, liquids and solids.

2. Experimental techniques used in the measurement of a particular property of gases, liquids and solids.

3. Actual experimental data on the measured values of a particular property for any reported substance.

Sources of Information

According to Dr. Y. S. Touloukian, director, the Center's responsibility is about equally divided between a study of available literature and the supervision of new experimental research. The channels through which information is gathered include: 1) abstractions of publications in both foreign languages and English; 2) governmental and industrial research reports; 3) reports of private research institutions, including graduate student research in some 200 science and engineering schools; and 4) cooperative working arrangements for exchange of research results and information with major national and international institutions in this country and abroad.

Each year the Center proposes to issue a special "Bibliography on Thermophysical Properties." The first volume, which is now available, contains some 15,000 bibliographic items.

Scientific Development Aim of University Group

Twenty-six leading educational and research institutions have formed an inter-university corporation known as Associated Midwest Universities (AMU). Functions of the new organization as outlined in the articles of incorporation are:

1. To provide, encourage and conduct research and education in all branches of science including, but not limited to, nuclear science in

Molding bag of FAIRPRENE® demonstrates extraordinary strength and durability

Shown above is the last stage in an internal molding process that uses an inflated bag of "Fairprene" synthetic rubber sheet stock as the core. This is where the bag undergoes greatest strain, being drawn through a 2½" opening in the formed tank. But bags of strong and flexible "Fairprene"* resist the wear and tear—permit more than 80 complete molding operations, as compared with only 20 when ordinary materials were used.

Structural Fibers, Inc., of Chardon, Ohio, found only "Fairprene" could withstand the extraordinary heat, pressure and abrasion involved in their internal molding process.

This is an example of the superior performance of "Fairprene" that might prove useful for your product or process. If you need material resistant to gas, oils, solvents or corrosive chemicals, abrasion or flex cracking—materials that retain their properties at −100°F. or 500°F. . . . or possess superior insulation or anti-stick properties, there's a Du Pont coated fabric or sheet stock to do the job. And to help you use these materials most effectively, you can call on free technical help from Du Pont. For more specific information on the variety of "Fairprene" materials available, mail the coupon.

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DU PONT INDUSTRIAL COATED FABRICS

COATING MEDIUMS

Neoprene • Buna-N • Silicone • Polyacrylate
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Cotton • Nylon • "Dacron"† • Asbestos
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Also elastomer sheet stocks without fabric inserts and cements

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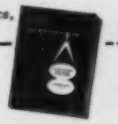

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Please send me further information about coated fabrics.

I am interested in using a coated fabric for_____

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MicroRold®

stainless steel soars with ATLAS ICBM on first full range flight!

U. S. missile program one step nearer to complete operational capability.

On the evening of November 28, 1958, a 100-ton ATLAS lifted from its pad at Cape Canaveral and arched majestically into the heavens. 30 minutes later its nose cone shot into the Atlantic, marking the first successful completion of its fully-programmed distance of 6300 statute miles.

The main part of the ATLAS structure is literally a huge fuel tank, the skin of which is thin gauge MicroRold stainless steel. Important factors in selection of stainless steel for the outer skin of the ATLAS are—great strength at both high and low temperatures, resistance to corrosive exotic fuels and good workability.

The stainless skin, supplied exclusively by Washington Steel, requires extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

NOW IN ORBIT!

4½ ton third stage
118 to 625 mile altitude
December 18, 1958

WASHINGTON STEEL CORPORATION

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relation to all other fields of science.

2. To establish means for facilitating the use of the Argonne National Laboratory and other laboratories by duly qualified personnel and students from the several cooperating institutions and other research and educational institutions.

3. To establish, maintain and operate laboratories and other facilities as necessary for research and education.

Headquarters for AMU will be at the Argonne National Laboratory's main site near Lemont, Ill.

Courses Offered in Plastics Technology

Four courses in plastics technology are presently being conducted by the Special Courses Div., Newark College of Engineering.

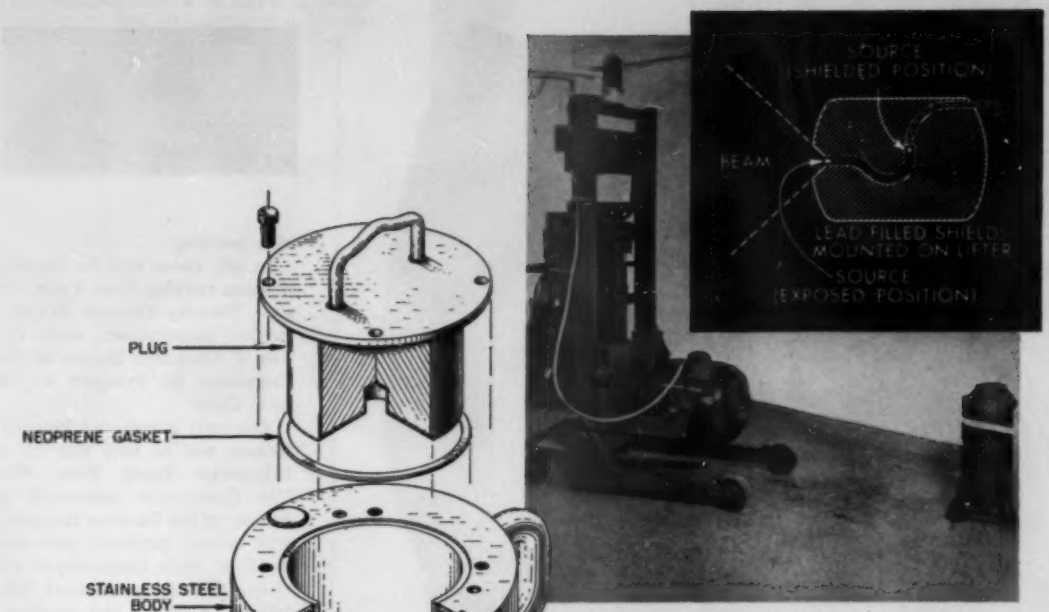
The courses are: "Compression and Transfer Molding," "Plastic Mold Design," "Thermoplastic Process Techniques," and "Testing and Control of Plastics Properties." According to Professor C. H. Stephans, director of the Special Courses Div., the courses may be taken individually or as part of a full three year certificate program.

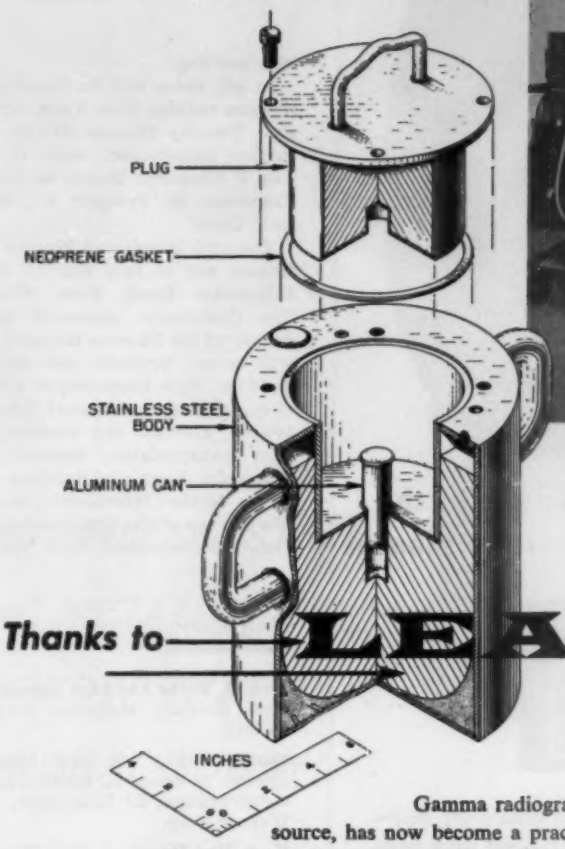
Thus far, seven such courses have been offered since September and three more are planned for the coming term. For further information, write to the Special Courses Div., Newark College of Engineering, 367 High St., Newark 2, N. J.

Two Plastics Groups to Hold Meetings

Two leading plastics technical groups will hold conferences within the next few weeks.

The 15th annual Technical Conference of the Society of Plastics Engineers is set for Jan 27-30 at the Hotel Commodore, New York City. Some of the topics scheduled to be covered: latest developments in stereospecific polymers, nondestructive testing, thermoforming, extrusion, injection molding, high temperature insulation, test methods, cellular plastics, epoxy resins, adhesives, new materials and compres-





Above: Directional gamma radiography equipment is shown in the photograph. The drawing shows how the lead container serves both to direct the rays and to shield personnel from dangerous radiation exposure. *Courtesy: Technical Operations, Inc.*

Left: Returnable container for Cobalt 60. *Courtesy: Oak Ridge Nat'l. Laboratory*

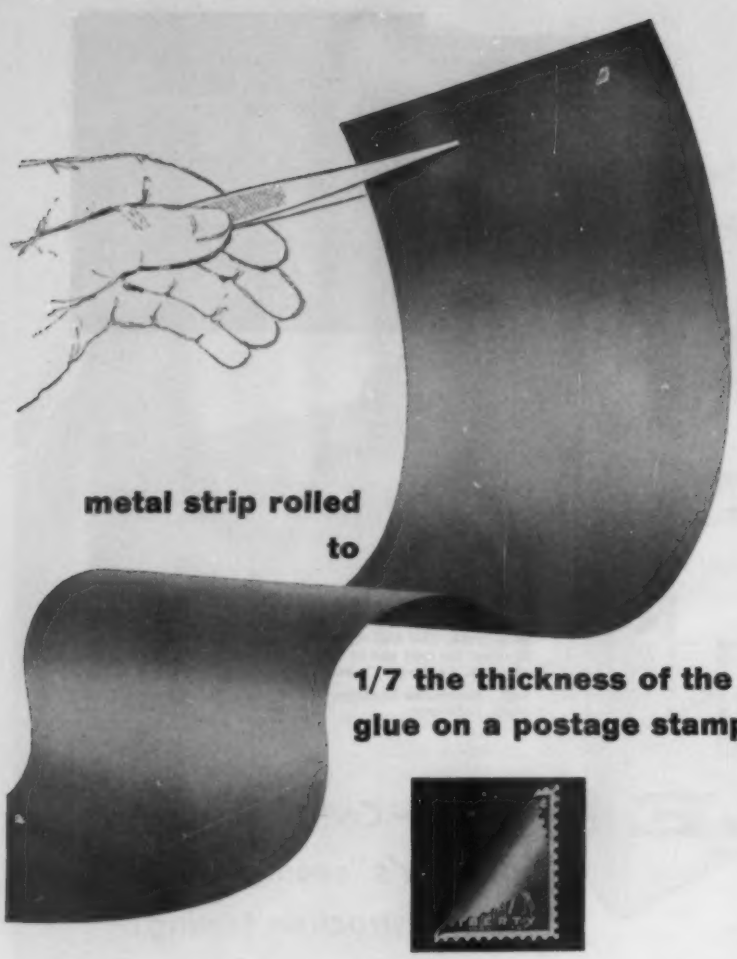
Thanks to LEAD — *Co^{60} is becoming industry's "seeing-eye" in non-destructive testing!*

Gamma radiography, utilizing Cobalt 60 as the self-generating "light" source, has now become a practical and low-cost industrial tool in the vital field of quality control. This has been made possible by (a) the availability of Cobalt 60 from the nation's nuclear reactors and (b) by taking advantage of the inherent and incomparable density of the metal lead as a material of construction for portable "safes" containing Cobalt 60 or other high-energy radioisotopes. As a shielding material, lead prevents off-target penetration of the dangerous gamma rays. The thickness of the lead shield is, of course, governed by the penetrating power of the rays emitted. Oak Ridge National Laboratory specifications for a Cobalt 60 container read as follows:

TYPE OF CONTAINER	TYPE OF MATERIAL SHIPPED	MAXIMUM ACTIVITY		THICKNESS OF LEAD SHIELD (in.)	TOTAL WEIGHT OF ASSEMBLED CONTAINER (lb)
		Radioisotope	Amount		
Returnable	Unseparated solids, gamma emitters	Co^{60}	1 curie	4	450
			5 curies	5	680
			25 curies	6	810
			180 curies	7 1/2	1320

The property of density has made lead, one of the first metals utilized by man, an important factor in a new and rapidly expanding industry with unlimited potentials... the harnessing of nuclear energy.

For more information, turn to Reader Service card, circle No. 410



Here is metal strip—available in virtually any alloy—produced in thicknesses ranging from .010" to .0001". (The glue on a stamp measures .0007".) Many of the miniaturization problems facing designers are being solved today by this ultra-thin strip and foil from the Precision Metals Division of the Hamilton Watch Company.

When product emphasis is on compactness and lightness, Precision Metals Division strip and foil will meet your exact mechanical, magnetic and physical specifications. For production orders or the development of new designs, this ultra-thin strip is available in any quantity. Special alloys to your own specification can also be made and furnished in the form you require.

A new 8-page facilities booklet illustrates and describes the operation of the Precision Metals Division, and shows how your precision metals problems can be solved practically and economically. Write on your letterhead today to Dept. DE-I.

Hamilton Watch Company

Precision Metals Division / Lancaster, Pennsylvania

Creator of the world's first electric watch

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sion molding.

In all, there will be 26 separate sessions running from 9 a.m. to 4:30 p.m., Tuesday through Friday. For further information, write to William C. Cleworth, Society of Plastics Engineers, 65 Prospect St., Stamford, Conn.

The 14th Reinforced Plastics Conference will be held Feb 3-5 at the Edgewater Beach Hotel, Chicago. The Conference, sponsored by the Society of the Plastics Industry, Inc., will cover: preform and mat die molding, high temperature applications, joining, mechanical behavior, tooling, aircraft and missiles, premix, transportation, research, raw materials, boats and building.

For further information, write to the Society of the Plastics Industry, Inc., 250 Park Ave., New York 17.

Engineers

Hans J. Heine has been named technical director, Malleable Founders Society.

Eugene Bollay has been appointed director of research, meteorology instrumentation, BJ Electronics, Borg-Warner Corp.

H. A. Roy Binney, British Standards Institution, has received the Standards Engineers Society's highest award of Honorary Life Fellow.

Ellis P. Hansen has been appointed chief engineer, Steam Turbine Dept., Allis-Chalmers Mfg. Co.

J. D. Mattimore has been named vice president, product engineering and research, Tube Turns Div., Chemetron Corp.

S. William Riley has been appointed chief engineer, Quaker Rubber Div., H. K. Porter Co., Inc.

Dr. Howard L. Gerhart is now director of research and development, Paint and Brush Div., Pittsburgh Plate Glass Co.

Dr. A. L. Feild has been named director of stainless steel research, **R. L. Davidson,** director of chemical research, and **K. Oganowski,** director of metallic coatings, Research Div., Armco Steel Corp.

Joseph H. Brennan, Electro Metallurgical Co., has received the Frank J. Tone Medal Award, presented annually by the Niagara Frontier

For more information, circle No. 472 ➤

This beautiful sculpture appropriately named "Flight of Progress" by Robert Edward Hamilton, stands in the lobby of the Detroit offices of the Stainless and Strip Division of Jones & Laughlin Steel Corporation.

J & L STAINLESS STEEL ... THE METAL OF TOMORROW THAT'S FUNCTIONAL TODAY!

The combination of inherent physical and corrosion-resistant properties of Stainless Steel qualify it above all other metals for basic functional engineering application. Designers and engineers use it because of its high degree of efficiency. The ability of Stainless to fabricate readily into intricate designs, its high tensile strength, its resistance to distortion in extreme hot or cold applications plus its corrosion resistance add up to advantages no other commercial metal can offer.

It is recognized that the application of Stainless for engineering and product design is still in its infancy. The increasing use of J & L Stainless Steel in industry points to a future of broad scope. Many of the requirements for atomic energy, guided missiles, aircraft, turbine engines, and other advanced designs for the future depend upon the qualities that only Stainless Steel can offer.

The most modern and complete facilities in the industry make Jones & Laughlin your best source for consistent quality Stainless Steel. Our special metallurgical service insures complete satisfaction in the fabrication of your products.

Improve your Products with . . .

J&L STEEL STAINLESS

SHEET • STRIP • BAR • WIRE

Helpful data sheets and manuals are now available:

1. Laboratory Corrosion Data.
2. Data Sheets (please specify the grades in which you are interested).
3. Stainless Sheet and Strip Manual.

Write for your copy today.

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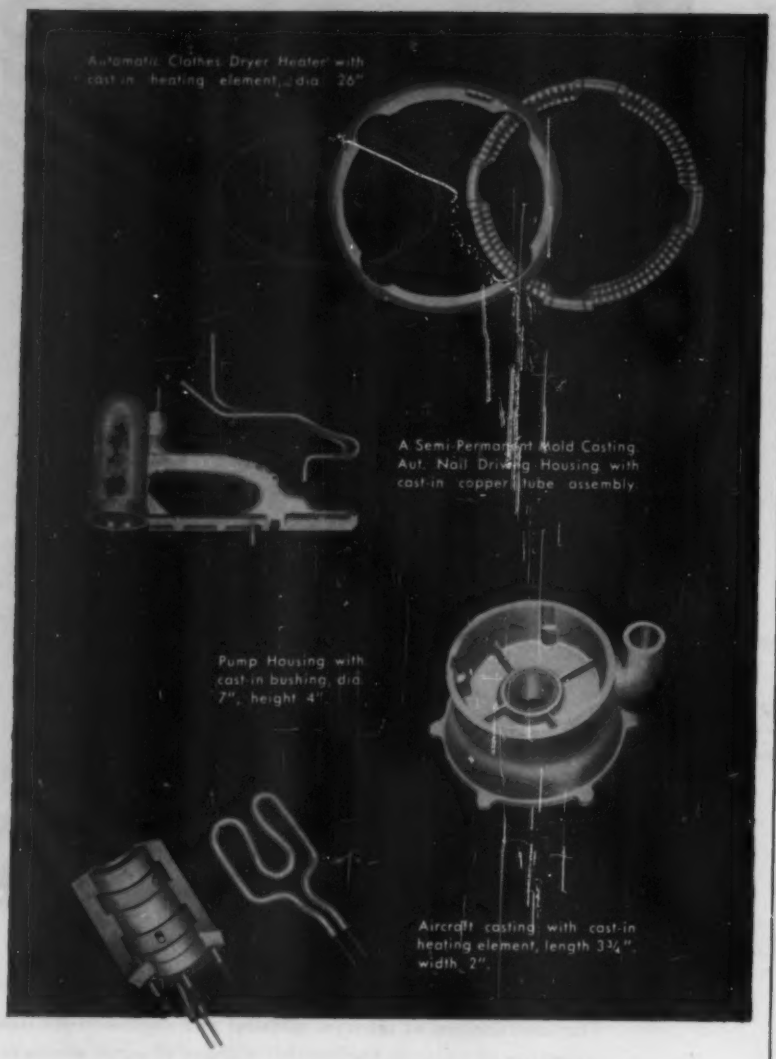
Automatic Clothes Dryer Heater with cast-in heating element, dia. 26"
A Semi-Permanent Mold Casting Aut. Nail Driving Housing with cast-in copper tube assembly
Pump Housing with cast-in bushing, dia. 7", height 4"
Aircraft casting with cast-in heating element, length 3¾", width 2"

COMBINATION PERFORMANCES "HARNESSED" WITH ALUMINUM PERMANENT MOLD casting

Your product design requirements may dictate a light weight, rust-proof casting, tailored to perform with a heating element, bushing or insert. ALUMINUM PERMANENT MOLD casting is the answer, as it is superior to other casting methods for holding and positioning metals selected for integral performances.

Shown here are examples of ALUMINUM PERMANENT MOLD CASTINGS already in use. All requiring the physical advantages of aluminum with bearing metals to resist frictional wear, and conductive metals for varied wattage loads. At EXALCO these are common requirements and create no production challenge to our skilled permanent mold casting engineers.

Your "finished product appearance" may be of primary importance. Our DURAGLAZE was developed by us to provide a finish that cannot crack or chip. It is mechanically applied to any flat or contour surface and assures greater durability than chemical and electrochemical finishes.

Feel free to write us for production procedure and estimates of aluminum castings with or without cast-in features.

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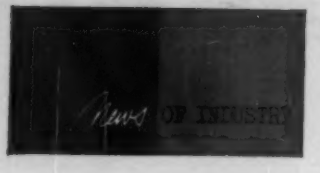


Section of American Institute of Mining, Metallurgical, and Petroleum Engineers for outstanding and important contributions to the science and practice of metallurgy.

Henry J. Egen, Jr., has been appointed manager, tool engineering and metal fabrication, Government and Industrial Div., Philco Corp.

Ernest E. Michaels, Chicago Bridge & Iron Co., has been elected to a three-year term as chairman of the Welding Research Council of the Engineering Foundation.

Roy C. Ritchart has been appointed assistant chief engineer, San Diego branch, Stromberg-Carlson, a division of General Dynamics Corp.

Dr. C. M. Vanderwaart has been named manager, Process Design Dept., Engineering and Construction Div., American Cyanamid Co.

Richard M. Bush has been appointed senior consultant, Washington, D.C. staff, Ebasco Services Inc.

Norman E. Bonn has been named director of research, Pyrometer Co. of America.

Fred F. Miller has been named vice president in charge of engineering, Gear Grinding Machine Co.

F. A. Wagoner has been appointed manager, Plant Engineering Dept., Tractor and Implement Div., Ford Motor Co.

Eugene A. Nedwick has been named manager, Strip Steel Div., Peterson Steels, Inc.

Dr. Hyman Chessin has been appointed director of research and development, Van der Horst Corp. of America.

J. S. Urbanik has been appointed manager of plant operations, Electrical Conductor Div., Kaiser Aluminum & Chemical Corp.

Dr. Hack Arroe is now head of Denver Research Institute's Physics Div.

Melvin F. House, Jr., has been named plant superintendent, Michigan Seamless Tube Co.

Dr. Samuel Herrick is now special consultant, Airborne Equipment Dept., Librascope, Inc.

Sam A. Wenk has joined the consulting staff of Applied Radiation Corp.

John S. Overholser has been named director of research engineering, **Kenneth E. Wilcox** chief engineer, and **Rex C. Bean** assistant chief engineer, Tamar Electronics, Inc.

(News of Companies on p 188)

Cutaway view of Federal Pacific's new circuit breaker showing TRUFLEX parts.

Federal Pacific Chooses Truflex® Thermostat Metal Assemblies for new Circuit Breaker

In designing its AB circuit breakers, Federal Pacific Electric, like more and more manufacturers, turned to General Plate for TRUFLEX Thermostat Metal Assemblies. Here's the reaction of C. A. Schmidt, Manager of Federal Pacific's Products Department:

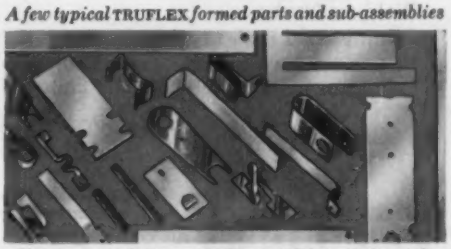
"The TRUFLEX *Thermostat Metal Assemblies in our new AB breaker equipment have more than proven their dependability and we are more than satisfied with the performance of these* TRUFLEX *components."*

General Plate manufactures these TRUFLEX Assemblies to Federal Pacific's exacting specifications and every piece is a duplicate of the original. Today General Plate makes TRUFLEX parts and assemblies for hundreds of manufacturers who have found that TRUFLEX means better control, indication and compensation of temperature in a wide range of products.

Here's why:

- **Truflex parts** and assemblies are engineered to your specifications — made with precision and uniformity, ready for installation.
- **This eliminates** the need for you to carry out prolonged experimental work and provide special manufacturing equipment. Expensive calibrating operations are not necessary when you use TRUFLEX parts.
- **If you prefer** to make your own parts, TRUFLEX metals are available in extra long coils or flat strips manufactured to exact specifications.

A few typical TRUFLEX *formed parts and sub-assemblies*



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For many pressure vessel requirements, progressive designers are specifying economical Lenape flanges and seamless weld end extensions in place of more costly long welding necks in I.D. sizes from 16" to 24".

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LENAPE FLANGES OFFER:

- Full I.D. opening for easier access and replacement of vessel internals.
- Wall thickness equivalent to more expensive Seamless Welding Necks.
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- Positive flange cost economy.

LENAPE SEAMLESS EXTENSIONS OFFER:

- Full I.D. opening free from constrictions imposed by pipe.
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- Inherent reinforcement.

IN COMBINATION:

- Economy in lengths beyond 12" overall as compared to Seamless Welding Necks.
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- Extension may first be welded to vessel, then flange welded to extension without refacing the flange.

Write today for detailed specifications.

See our standard line of pressure vessel connections on pages 1128-1129 in the 1958 Chemical Engineering Catalog.

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LENAPE HYDRAULIC PRESSING & FORGING CO.
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RED MAN PRODUCTS

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News of Industry

Companies

Riker Laboratories, Inc., has moved to new headquarters at 19901 Nordhoff St., Northridge, Calif.

Air Reduction Sales Co. has established a Special Products Dept., to develop specialized products for industrial use.

Hammond Valve Corp., a subsidiary of Consolidated Diesel Electric Corp., has acquired **Hammond Brass Works, Inc.**

Navan Products, Inc., a subsidiary of North American Aviation, Inc., has moved to 900 N. Sepulveda Blvd., Airport Station, Los Angeles 45, Calif.

Barden Corp. has opened a $2½-million plant, located in Danbury, Conn., for the manufacture of instrument precision ball bearings.

Materials Research Corp. has established an Instruments for Industry Div. for the design and construction of scientific machines for industrial research laboratories.

United-Carr Fastener Corp. has acquired **New England Tape Co.**, Hudson, Mass.

Turco Products, Inc., has broken ground for a new 66,000-sq ft, national headquarters in Wilmington, Calif.

Flexonics Research Laboratories, a new division of Flexonics Corp., has been established in Elgin, Ill., "to provide testing and development service on a contract basis to industry and to developmental agencies of the Government."

Telecomputing Corp. has acquired **Frank R. Cook Co.** of Denver, Colo.

Marquardt Aircraft Co. has acquired **Cooper Development Corp.**, which will be operated as a wholly-owned subsidiary of Marquardt.

Anderson Chemical Co., a division of Stauffer Chemical Co., has announced plans for a $200,000 expansion program of its manufacturing and laboratory facilities at Weston, Mich.

Thompson Ramo Wooldridge Inc. is a new company resulting from the merger of **Ramo-Wooldridge Corp.** and **Thompson Products, Inc.**

Fairchild Semiconductor Corp. has constructed a new 65,000-sq ft plant in Mountain View, Calif., to provide more space for its research projects.

Olin Mathieson Chemical Corp. will complete its $4-million metallurgical

RARE EARTH AND YTTRIUM METALS

available in high purity and commercial grades

a report by LINDSAY

If you are interested in the rare earths in metal form for research and production purposes, you will find it helpful to talk with us at Lindsay.

Rare earth and yttrium metals, in *both* high purity and commercial grades, are now available for prompt shipment from our inventory, in experimental quantities.

Both high purity and commercial grades are furnished primarily in the form of ingots or lumps. You will find costs reasonable and advantageous for your research on product development and production operations.

Lindsay has been working with the rare earths for nearly 60 years and is the world's largest producer of salts and compounds of thorium, rare earths and yttrium. Five years ago, Lindsay pioneered the first commercially installed rare earth ion exchange units for the production of separated rare earths in purities up to 99.99%.

HIGH PURITY RARE EARTH METALS

Maximum rare earth impurities – 0.1%

YTTRIUM	NEODYMIUM	TERBIUM	THULIUM
LANTHANUM	SAMARIUM	DYSPROSIUM	YTTERBIUM
CERIUM	EUROPIUM	HOLMIUM	LUTETIUM
PRASEODYMIUM	GADOLINIUM	ERBIUM	YTTRIUM (lower purity grade)

RARE EARTH METALS

Commercial Grades

CERIUM-FREE MISCH METAL	DIDYMIUM, commercial grade
MISCH METAL	CERIUM, commercial grade
LANTHANUM, commercial grade	THORIUM, commercial grade

LINDSAY EXPANDS SERVICE

As a result of increasing interest in the potential advantages of using rare earth and yttrium metals, Lindsay is pleased now to announce the expansion of its service facilities to offer these fascinating and extremely useful materials in metal form.

We hope we can tempt you to develop a healthy curiosity about the rare earths. During recent years they have been accepted as essential components in the production of materials in a broad cross-section of the nation's chemical, manufacturing, electronic and atomic industries.

You are quite likely to have your own ideas for possible uses of rare earth metals in production operations or in your research on product development projects. We would be happy to tell you about some of the many ways in which these materials are being used.

We can, however, furnish you a considerable amount of interesting and revealing technical data on rare earth and yttrium metals, including a detailed tabulation of properties, purities and costs.

Please ask for our bulletin "Rare Earth and Yttrium Metals." It will be sent to you promptly.

PLEASE ADDRESS INQUIRIES TO

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American Potash & Chemical Corporation

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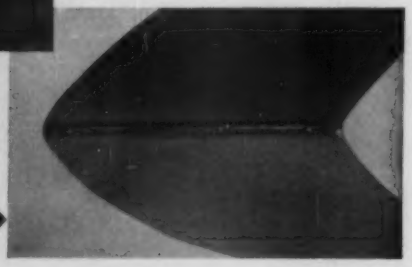
Precision-Annealing Gives WRM PHOSPHOR BRONZE extra stamina and formability

These photos will give you an idea of how Waterbury Rolling Mills *precision-annealed* phosphor bronze can improve your production.



Close up shows how WRM *precision-annealed* spring temper phosphor bronze withstands severe bend.

Close up of ordinary-annealed spring temper phosphor bronze shows surface beginning to rupture at the bend.

By a closely-controlled anneal prior to finishing, Waterbury produces spring-temper phosphor bronze with up to 3 times normal formability (elongation) plus higher fatigue life. The finer, more uniform grain structure produced by this process also improves surface finish and insures consistent production quality.

Over 50 years of specialization enables WRM to produce phosphor bronze with special ability for your application.

Available in strip, sheet or coil.

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WR-71

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research center at New Haven, Conn., by the middle of 1959.

Allen Mfg. Co. has moved to its new main office and manufacturing plant at Bloomfield, Conn.

Westinghouse Electric Corp.'s Switchgear Distribution Apparatus Dept. has moved to a new building in Bloomington, Ind.

James F. Lincoln Arc Welding Foundation has announced a $50,000 Machine Design Award Program "to encourage and stimulate advance in the knowledge and application of the arc welding process." The closing date for the contest is July 20, 1959.

Peter J. Schweitzer Div., Kimberly-Clark Corp., is the new name for **Peter J. Schweitzer, Inc.**

Pittsburgh Plate Glass Co. has acquired the assets of **Barium Reduction Corp.**

Coast Instrument, Inc., has opened a new industrial optics plant at 5355 Long Beach Blvd., Long Beach 5, Calif.

Bradley Semiconductor Corp. is the new name for **Bradley Laboratories, Inc.**

Clark Bros. Co., a division of Dresser Industries, Inc., has formed a **Nuclear Products Dept.**

Eclipse Fuel Engineering Co., Rockford, Ill., has purchased **Norwalk Valve Co.**

Pittsburgh Coke & Chemical Co. has completed a new 2-million-pound-per-year facility for the production of fumaric acid, used in the production of plastics, paints and chemicals.

Societies

American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., announces the following 1959 officers: president—Howard C. Pyle, Monterey Oil Co.; president-elect—Dr. Joseph L. Gillson, E. I. du Pont de Nemours & Co., Inc.; vice presidents—Thomas C. Frick, Atlantic Refining Co.; Dr. Walter R. Hibbard, Jr., General Electric Co.; Elmer A. Jones, St. Joseph Lead Co.; and John C. Kinnear, Jr., Kennecott Copper Co. Directors named for three years are: John S. Bell, Humble Oil & Refining Co.; Dr. John C. Chipman, Massachusetts Institute of Technology; Dr. Arthur B. Cummins, Johns-Manville Research Center; Dr.

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do a better job for less

The current trend away from older traditional materials to NYLON, *HI-FLEX, POLYETHYLENE, BUTYRATE and VINYL for spacers and rollers attest to the superiority of these plastic materials in this application. Plastic spacers cost less, look better and are far more durable. Noise and friction is reduced, rust danger eliminated and deterioration minimized.

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WRITE for descriptive literature on our facilities and technical assistance on small components.

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For more information, circle No. 507

Carleton C. Long, St. Joseph Lead Co.; and Jerome W. Woomer, consultant.

American Pewter Guild is a newly formed nonprofit association located at 492 W. Sixth Ave., Columbus 1, Ohio.

American Foundrymen's Society has elected the following four new officers: chief administrative officer—William W. Maloney; technical director—S. C. Massari; treasurer—Edward R. May; and secretary—Ashley B. Sinnett.

Gray Iron Founders' Society, Inc. announces the following winners of its 1958 annual design contest awards: first prize—Earl R. Zuehlke, Black-Clawson Co.; and second prize—Richard Q. Rinehuls, Automation Services, Inc. Tied for third prize are: K. Rudolph, McCulloch Motors Corp.; Orville W. Hoffman, General Electric Co.; A. G. Bellos, Sandy Hill Iron & Brass Works; Ralph V. Morr, Avco Mfg. Corp.; and William A. Williams, consulting engineer.

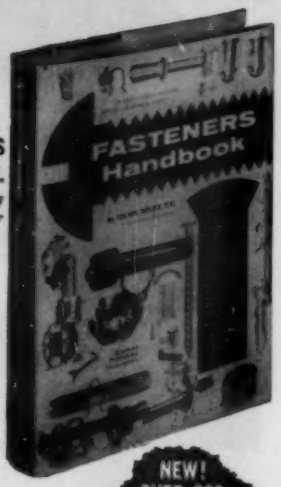
American Society for Metals announces the following 1959 officers: president—Dr. Clarence O. Lorig, Battelle Memorial Institute; vice president—Walter Crafts, Electro Metallurgical Co.; treasurer—Dr. Robert H. Aborn, U. S. Steel Corp.; secretary—Walter D. Jominy, Chrysler Corp.; and trustees—G. MacDonald Young, Aluminum Co. of Canada; Dr. Earl R. Parker, University of California; Merrill A. Scheil, A. O. Smith Corp.; Dr. John H. Hollomon, General Electric Co.; and Dr. E. Eugene Stansbury, University of Tennessee.

Gray Iron Founders' Society, Inc., has elected the following officers: president—Albert M. Nutter, E. L. LeBaron Foundry Co.; vice president—J. E. Quest, Quest Mfg. Co.; secretary—William A. Hepburn, John T. Hepburn, Ltd.; and treasurer—C. R. Garland, W. O. Larson Foundry Co. Directors are: J. T. Boyd, Goldens' Foundry and Machine Co.; W. G. Greenlee, Greenlee Foundry Co.; C. R. Gregg, Gregg Iron Foundry; and A. B. Sayre, American Abrasive Metals Co. Donald H. Workman was re-appointed executive vice president.

Assn. of Consulting Chemists and Chemical Engineers, Inc., announces the following 1959 officers: president—Erwin DiCyan, DiCyan & Brown; vice president—Foster D. Snell, Foster D. Snell, Inc.; treasurer—Arthur Linz, consulting chemist; and secretary—W. C. Bowden, Ledoux & Co., Inc. *(News of Meetings on p 194)*

Details, ideas, sources for all fastening needs . . .

FASTENERS Handbook



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FASTENERS HANDBOOK greatly facilitates the review of available information, the making of a valid selection, and contacting the sources of supply. It can be used by design engineers, patent attorneys, sales personnel, fastener distributors and jobbers—in fact, anyone who needs solid information on fasteners available for mechanical assembly.

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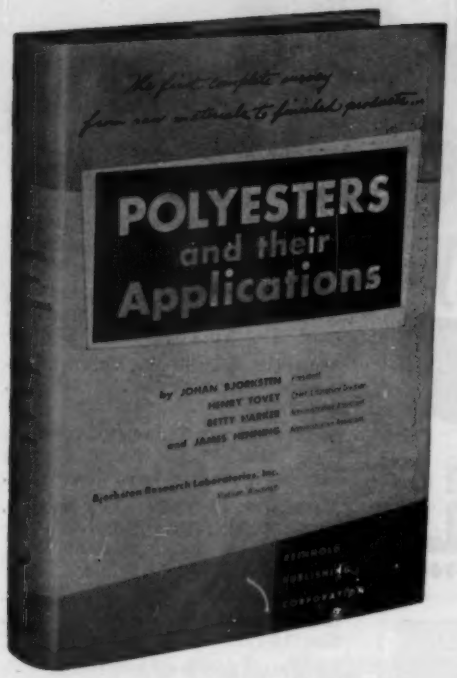
POLYESTERS

and their Applications



1956, 626 pages, $10.00

by JOHAN BJORKSTEN
President

HENRY TOVEY
Chief, Literature Division

BETTY HARKER
Administrative Assistant

and JAMES HENNING
Administrative Assistant

**all of Bjorksten Research Laboratories, Inc.
Madison, Wisconsin**

This book is the first comprehensive survey of the entire polyester field from raw materials to fabricated product. The text and annotated bibliography of over 3300 references cover most phases of the production and use of polyesters. You will find here a storehouse of valuable information and a tremendous time-saver in seeking background information. Now you can quickly locate any patents or literature bearing on some particular phase of the polyester field. Included are not only the unsaturated polyesters used in molding, casting, coating, impregnating, and laminating, but also the saturated polyesters used in production of fibers, films, elastomers, and foamed plastics.

This fund of information has been painstakingly assembled for many years by the Bjorksten Research Laboratories. Periodic volumes will be published when merited, to make them a basic reference work covering the current status of the field and indicating the problems which must be overcome for further advancement and the directions of future trends.

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4 TESTING
Introduction; Raw Materials; Resins and Plastics; Equipment for Testing Plastics; Catalysts; Glass Fillers; Design Data and Nondestructive Tests

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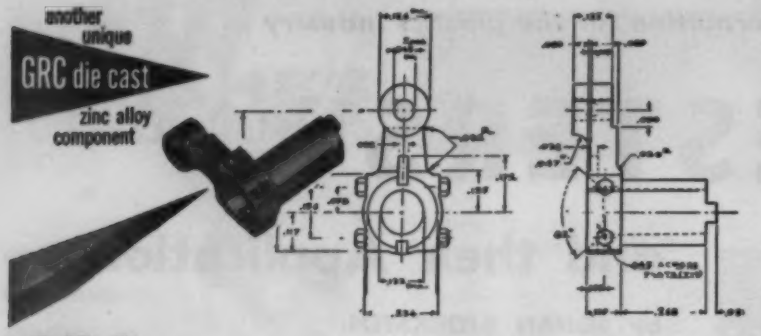

GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves. Less than half an inch overall. It is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean—no trimming, no assembly, no scrap loss.

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Typical Stalker fabrication. Nozzle assembly of nimonic alloy. (Photo courtesy of Continental Aviation and Engineering Corp.)

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Meetings

5TH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL, American Society for Quality Control, Institute of Radio Engineers, American Institute of Electrical Engineers, and Electronic Industries Assn. Philadelphia. Jan 12-14.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York City. Jan 19-24.

SOCIETY OF PLASTICS ENGINEERS, INC., 15th SPE annual technical conference. New York City. Jan 27-30.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. Pittsburgh. Feb 2-6.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 14th SPI Reinforced Plastics Div. conference. Chicago. Feb 3-5.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, annual meeting. San Francisco. Feb 15-19.

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th annual meeting. Chicago. Mar 16-17.

AMERICAN SOCIETY FOR METALS, 11th Western metal exposition. Los Angeles. Mar 16-20.

AMERICAN SOCIETY FOR QUALITY CONTROL, Rochester Section, 15th annual quality control clinic. Rochester, N. Y. Mar 26.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, conference on physical metallurgy of stress-corrosion fracture. Pittsburgh. Apr 2-3.

AMERICAN WELDING SOCIETY, 40th annual convention and welding exposition. Chicago. Apr 6-10.

METAL POWDER INDUSTRIES FEDERATION, annual meeting. Detroit. Apr 20-22.

INSTITUTE OF ENVIRONMENTAL ENGINEERS, third annual technical meeting and equipment show. Chicago. Apr 22-24.

METAL TREATING INSTITUTE, spring meeting. Hollywood, Calif. Apr 22-26.

ELECTROCHEMICAL SOCIETY, spring meeting. Philadelphia. May 3-7.

AMERICAN FOUNDRYMEN'S SOCIETY, 62nd foundry show and castings congress. Cleveland. May 19-23.

AMERICAN SOCIETY FOR TESTING MATERIALS, 62nd annual meeting. Atlantic City. June 21-26.

For more information, turn to Reader Service card, circle No. 454

Pioneer's Honeycomb...made of

Trevarno

Impregnated

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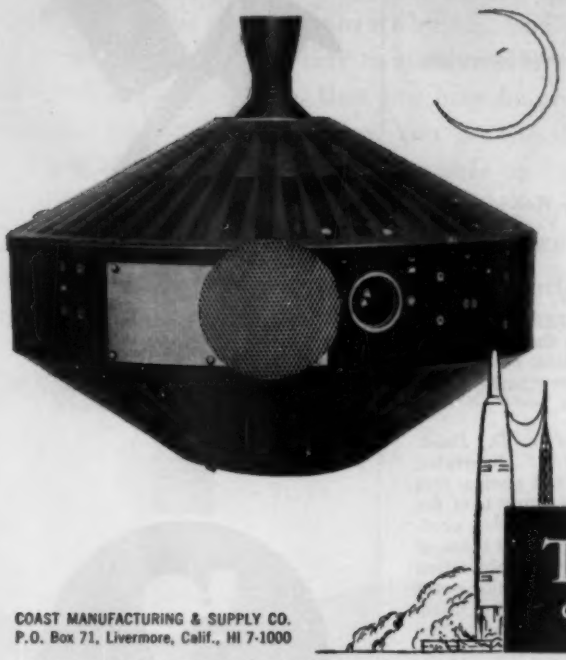

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Sub-Zero	SZH653	6.5	−85°F.	−75°F.	60"	28"	42¼"	47"	15"	18"
Sub-Zero	SZHC657	6.5	−140°F.	−125°F.	60"	28"	42¼"	47"	15"	18"
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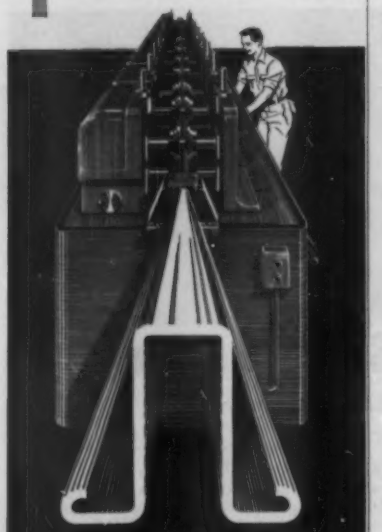

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Books

Books on Plastics. *Reinhold Publishing Corp., New York. Plastics Applications Series. Cloth, 5 by 7½ in.*

Vinyl Resins. *W. Mayo Smith. 1958. 286 pp. Price $5.75.* This book gives information on the production, consumption, properties, uses, types, chemistry, manufacture and fabrication of vinyl resins.

Cellulosics. *Walter D. Paist. 1958. 278 pp. Price $5.75.* Illustrated with tables, graphs and photos, this book summarizes the many uses for extruded and injection molded products, adhesives and coatings made of cellulose. The properties, fabrication and chemistry of such cellulosic materials as cellophane, rayon, nitrocellulose, cellulose acetate and ethyl cellulose are given.

Epoxy Resins. *Irving Skeist. 1958. 316 pp. Price $5.50.* The author, a chemical consultant specializing in plastics, clearly describes the properties and uses of epoxy potting and casting compounds, and adhesives. A special chapter, written by G. Somerville, describes the properties and uses of epoxy coatings. The book is well illustrated with photos and tables, and contains an extensive bibliography.

Introduction to Foundry Technology. *D. C. Ekey and W. P. Winter. McGraw-Hill Book Co., Inc., New York. 1958. Cloth, 6 by 9 in., 300 pp. Price $7*

The first part of this book comprises a series of lectures on the theoretical aspects of foundry technology. Subjects include: 1) sand molds and cores; 2) permanent mold and die casting methods; 3) centrifugal and investment casting processes; 4) melting of metals for casting; 5) molding machines; 6) metallurgical considerations of the ferrous alloys; and 7) cleaning and inspecting castings.

The second part provides operational information on numerous foundry processes.

Anti-Corrosion Manual. *Corrosion Prevention & Control, London, England. 1958. Cloth, 8½ by 11 in., 260 pp. Price $7*

This volume, the first of a series, gives properties, uses and chemical resistance of such materials as aluminum alloys, lead, nickel alloys, rubber, wood, tin, copper and copper alloys, plastics extrusions, stainless steels, tantalum, titanium and zirconium. The book also gives properties and uses of rubber and plastics paints, pre-paint treatments, vitreous enamel coatings, cadmium and tin electroplates, and pipe coatings.

Fourth National Symposium on Vacuum Technology Transactions: 1957. *Edited by Wilfred G. Matheson. Symposium Publications Div., Pergamon Press Inc., New York. 1958. Cloth, 8⅜ by 11¼ in., 188 pp. Price $12.50*

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Turning: Tools, Methods, Costs. *Walter G. Holmes. Reed Technical Service, Detroit. 1958. Cloth, 8¾ by 11¼ in., 240 pp. Price $7.50*

Although the subject matter of this book is concerned primarily with tools and tooling methods, a number of chapters contain information on machining aluminum, brass, steel, iron, plastics and titanium. The book is well illustrated with tables and charts.

Tooling for Metal Powder Parts. *George H. De Groat. McGraw-Hill Book Co., Inc., New York. 1958. Cloth, 6 by 9 in., 256 pp. Price $7.50*

Powder metallurgy has achieved a definite and important place in industry, and it is the intention of this book to present some of the problems encountered in using the process, to describe its limitations as well as advantages, and to present factual data on how it can be best applied. The various chapters cover the essential factors involved in designing parts, methods of production, preparation of powders, briquetting techniques, design of briquetting tools, and finishing operations including sizing, coining, machining, surface cleaning, heat treating and plating. The book contains a glossary of terms and a bibliography.

Industrial Carbon and Graphite. *Macmillan Co., New York. 1958. Cloth, 8½ by 11 in., 630 pp. Price $25.75*

Included in this book are over 60 papers given by American and European scientists at a conference on industrial carbon and graphite. Subjects discussed include: physical, chemical and electrical properties; crystal structure; manufacture and uses.

Reports

Machining cobalt MACHINING OF COBALT SUPERALLOYS. *C. T. Olofson and F. R. Morral, Battelle Memorial Institute. 1958. Available from Cobalt Information Center, c/o Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.*

Machining data and operating instructions are given for 22 cobalt superalloys and 3 cobalt metal-glass sealing alloys.

Radiation effects on paint EFFECTS OF NUCLEAR RADIATION ON MILITARY SPECIFICATION PAINTS. *Lloyd A. Horrocks, Wright Air Development Center. Nov '57. 31 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1 (PB 131599)*

Evaluates the effect of gamma radiation and heat on silicone-alkyd, fluorocarbon, nitrocellulose, phenolic and epoxy-based paints. Silicone-alkyd, alkyd and phenolic resin-based paints appear to be satisfactory after exposure to 1×10^9 r.

Welding aluminum ALUMINUM WELDERS TRAINING MANUAL: INERT GAS PROCESS. *1958. 144 pp. Kaiser Aluminum & Chemical Sales, Inc., Technical Publications Dept., 919 N. Michigan Ave., Chicago 11. Price $1*

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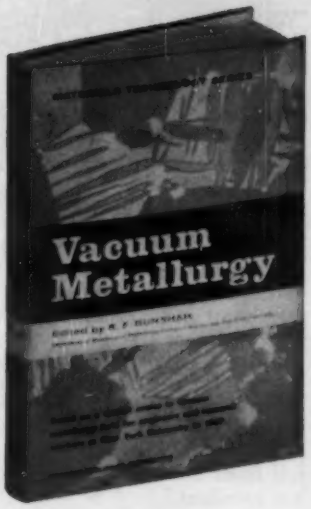

1958, 490 pages, $12.50

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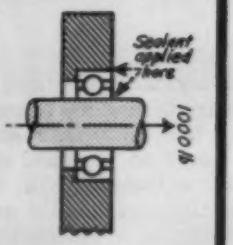

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of the manual discusses tungsten-inert-gas TIG and metal-inert-gas MIG are processes for welding aluminum. The second and third sections offer step-by-step exercises in setting up equipment, establishing an arc, and making butt and fillet welds.

Materials evaluation MATERIALS EVALUATION IN RELATION TO COMPONENT BEHAVIOR. *Dec '58. 632 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $8 (PB 131733)*

Included are papers given at the Third Sagamore Ordnance Materials Research Conference. The papers discuss: 1) evaluation of ferrous and nonferrous metals; 2) toughness of titanium alloy sheet; 3) testing of complex structures; 4) high temperature properties in relation to design; 5) stress corrosion and hydrogen embrittlement; and 6) evaluation of weldments.

Titanium as a hardener AGE-HARDENING CHARACTERISTICS OF A CAST ALLOY OF COPPER-6% TITANIUM. *H. Hekner, H. McCurdy and R. Edelman, Frankford Arsenal. July '58. 14 pp. Available from Office of Technical Service, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 131297)*

Discusses use of titanium scrap as a hardener for metal alloys. It was found that a copper-6% titanium alloy, when heat treated, has tensile properties exceeded only by those of beryllium copper. The alloy has substantially greater strength than the commercially used high strength manganese bronze.

Heat vs modulus EFFECT OF TEMPERATURE ON DYNAMIC MODULUS OF ELASTICITY OF SOME STRUCTURAL ALLOYS. *Lewis F. Vosteen, Langley Aeronautical Laboratory. Aug '58. 19 pp. Available from National Advisory Committee for Aeronautics, 1512 H St. NW, Washington 25, D. C. (TN 4318)*

The effect of temperature on Young's modulus of elasticity was determined for 2024-T3 and 7075-T6 aluminum alloys, AZ31A-O magnesium alloy, RS-120 titanium alloy, and type 302 stainless steel by flexural vibration tests of beam specimens at temperatures from room to 900 F. The data show that the dynamic modulus decreases with temperature but does not decrease as rapidly as the static modulus.

Die casting standards PRODUCT STANDARDS FOR DIE CASTINGS. *1958. 40 pp. American Die Casting Institute, 366 Madison Ave., New York 17, N. Y. Price $5*

Die casting standards, available in hard covered ring binders, consist of the following: 1) engineering or "E" series which covers tolerances, draft requirements, cored holes, flash removal and other details of die casting design; 2) metallurgical or "M" series which covers compositions, properties and characteristics of zinc, aluminum, brass and magnesium die castings; and 3) commercial or "C" series which covers the principal provisions of die casting purchasing contracts.

Measuring thickness THE MEASUREMENT OF THICKNESS. *George Keinath, National Bureau of Standards. Jan '59. 79 pp. Available from Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 50¢ (NBS No. 585)*

This publication surveys the available information on various methods and problems of measuring thickness in industry and science. The methods are treated in seven groups: mechanical, chemical, electrical, magnetic, optical, x-ray and radioactive radiation.

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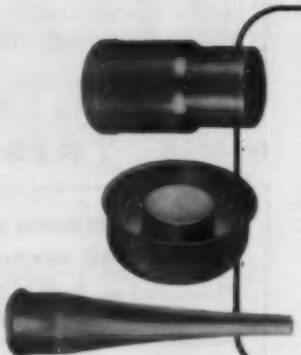

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MATERIALS IN DESIGN ENGINEERING

A REINHOLD PUBLICATION

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by H. R. Clauser
Editor

You Ask For It

Many of you who have been kind enough to answer our editorial questionnaires or who have sent us suggestions for improvement may wonder whether we really pay any attention to reader feed-back. The answer is that we certainly do. All suggestions and criticisms are carefully reviewed and then classified according to the nature of the comment. Thus, over a period of time we get a pretty good idea of what you like and don't like. And in this month's issue you will find proof that we do something about it.

You may have noticed that we have added a fast reading "At a Glance" page to the "Materials at Work" department (p 7). This new addition is a direct result of the high readership scores and the many favorable comments received by a similar page in our "What's New in Materials" department.

International Bright Spot

In these days when we hear so much about the seemingly endless squabbles between nations, it is encouraging to learn that in technical matters cooperation rather than discord is the prevalent mood.

An example is the International Organization for Standardization (ISO). This little-publicized organization, set up only 12 years ago, has already produced or approved an impressive body of standards. For example, in November the committee on plastics met in Washington and, among other actions, approved a list of 800 equivalent plastics terms in English, French and Russian (see p 177). This international glossary will certainly facilitate communication in the field of plastics.

Perhaps as important as the work being done by the ISO in the standards field, is the opportunity which meetings such as this afford for the informed exchange of ideas between technical people from the 40 member nations.

Principles That Count

What is perhaps the first formal college course on the principles of materials selection will begin at New York University's College of Engineering next month. It will be an elective for senior students in metallurgical engineering, and the course will be conducted by Prof. John Nielsen.

We were happy to learn that text for the course will be MATERIALS IN DESIGN ENGINEERING. Also, a number of entries from our Awards Competition will be used as case history examples of sound materials selection.

There Is Still Time

Speaking of the Awards Competition, there is still time to enter the current one. The deadline is Feb 2. You will find details on what and how to enter on p 114.

It is well worth entering your best job or jobs of the past year. You have already done the work, so it's merely a matter of putting it down on paper and sending it in.

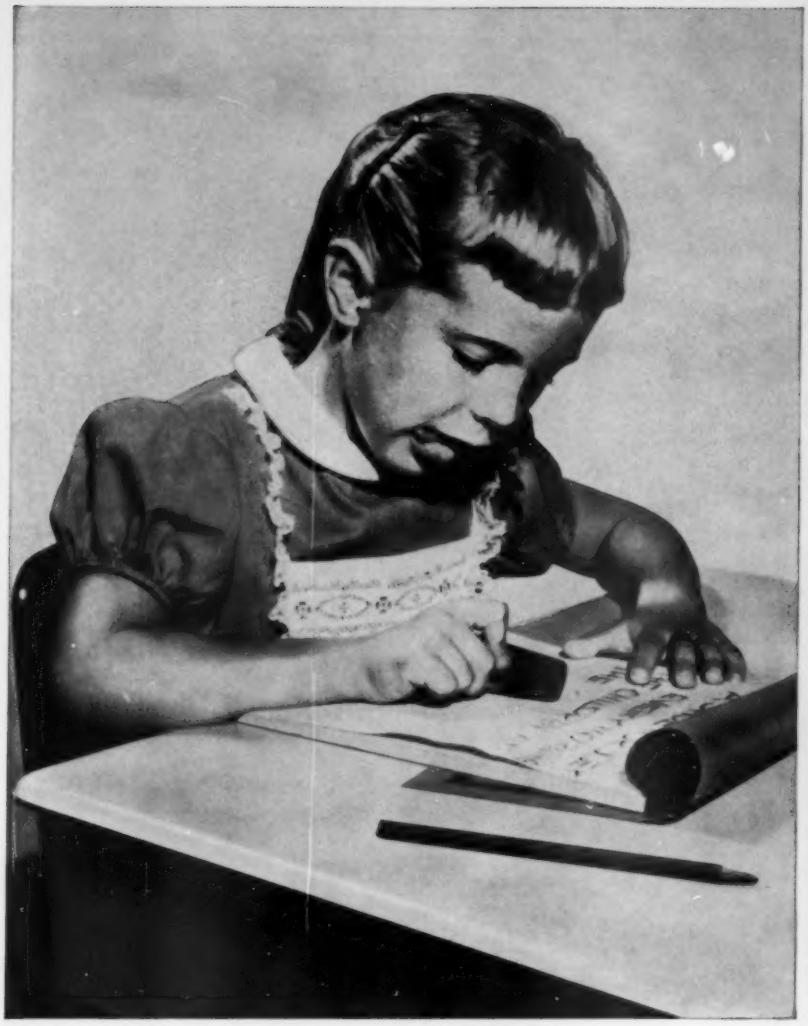
Make Iron in Your Back Yard

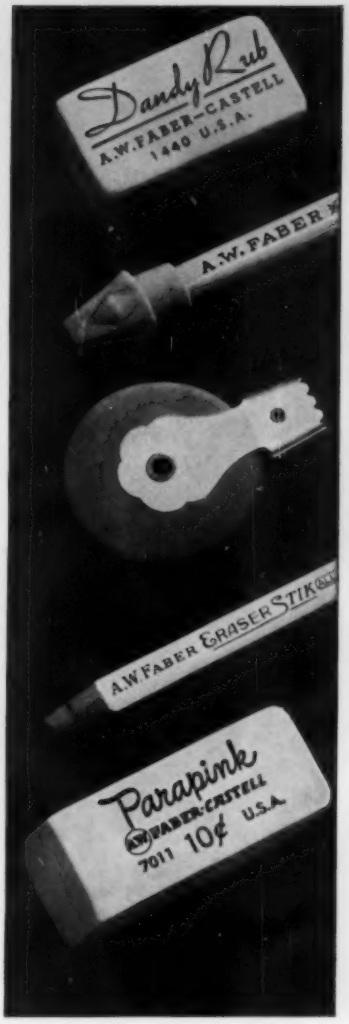
We read in a newspaper recently of the astonishing progress China is making industrially. Next year, for example, they hope to match Britain's steel production capacity.

Contributing significantly to this great increase in steel production are home-made "blast furnaces." There are some 300,000 to 700,000 of them. The people build these crude furnaces in their back yards. They are hardly bigger than a household fireplace, but apparently do a good job of converting scrap metal and ore into pig iron. Operating the furnaces is kind of a sideline for the people. They still work at their regular jobs ten hours a day, six days a week.

'Engineering for Eddie'

How would you explain the engineering profession to a group of youths who are trying to decide what field of work to train themselves for? It isn't an easy job. However, there is a 20-min film, "Engineering for Eddie," that can help you. It was produced by the College of Engineering of Ohio State University and is designed to serve as a guide to young people and their parents in evaluating the requirements and practical applications of engineering training. Through a series of scenes centered in the "fairy-tale world" of little Eddie Smith, the film answers four important questions: What is an engineer? Why is he needed? What does he need to know? How does he become an engineer?





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